BACHELOR OF ENGINEERING DEGREE/DEGREE WITH HONOURS IN ELECTRONIC AND COMMUNICATIONS ENGINEERING

Final Year Project Report

School of Electronic, Communication and Electrical Engineering

University of Hertfordshire

PC Oscilloscope USB based

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Date
April 2008

DECLARATION STATEMENT

I certify that the work submitted is my own and that any material derived or quoted from the published or unpublished work of other persons has been duly acknowledged (ref. UPR AS/C/6.1, Appendix I, Section 2 – Section on cheating and plagiarism)

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ABSTRACT

This report describes a comprehensible method to evaluate desired data in a graphical format that is a preferable and common way in the communication world. The discussion and implementation on PC oscilloscope simulation of the graphical data are also involved which should help reader to have a full and further understanding on this subject.

Using a top level structure diagram-flow chart to introduce the processes of project is a legible and informative manner. Also, in this report, the aspects and principle of related productions such as USB port & RS-232 cable is presented. In the end, the test results along with essential explanations are included as well.

ACKNOWLEDGEMENTS

Firstly, I would like to express my thanks to my project supervisor Dr. Georgios Pissanidis for his patience and intelligible guidance throughout this project.

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GLOSSARY

USB: Universal Serial Bus
DSP: Digital Signal Processing /Digital Signal Processor
RS-232: Recommend Standard-232
DAQ: Data Acquisition
VB: Visual Basic
COM: Component Object Model
UART: Universal asynchronous receiver/transmitter
DTE: Data Terminal Equipment
DCE: Data Communications Equipment
FIFO: First-In, First-Out
VCP: Virtual COM port
CPU: Central Processing Unit
MCU: Micro-programmed Control Unit
VID: Vendor ID
PID: Product ID
DAC: Digital- to-Analogue Converter
GDI+: Graphics Device Interface +
IDE: Integrated Development Environment

1. Introduction

This section based on feasibility report before contains a brief statement of background information and system description of the subject, the reasons for undertaking the work, the aims and objectives and the methods employed to achieve these objectives.

1.1-Background

In modern times, desired data information is frequently analyzed and utilized by people to develop business, industry and applications in various fields. As time goes on, the communication and data acquisition system have become core and popular techniques.

Generally speaking, communication is a process that allows human and animals and other living beings to exchange information by several methods in the world. It exists everywhere by means of many kinds of forms. Everything takes part in communication must understand a common language that is transferred with each other. With the development of science and technology, the ways are used to communicate have also improved.

Modern communication and measurement system designs are increasing in complexity and functionality as the latest high-performance processors and DSP enable new signal-processing techniques. What is more, the data transfer becomes much easier than before. The USB (Universal Serial Bus is a serial bus standard as interface or peripheral equipment to plug in PC) has got highest data transfer rate up to 8 Mbits/second. Nowadays, the USB specification is at version 2.0 (Up to 480 Mbit/s (USB 2.0) applications commonly. No matter what how much data is transferred only with the aid of one cable. In that case it will save much space cost.

Communication as defined in the RS232 standard is an asynchronous serial communication method. RS-232 is one of the most widely used techniques used to interface equipment to computers. It uses serial communications where one bit is sent along a line, at a time. This differs from parallel communications which send one or more bytes, at a time. The main advantage of serial communications over parallel communications is that a single wire is needed to transmit and another to receive. RS-232 is a standard that most computer and instrumentation companies comply with. [2]

Data acquisition sometimes called DAQ that is the sampling of the real world to generate data. It may take a variety of forms. At the simplest level, data acquisition can be accomplished by a person, using paper and pencil, recording readings from a volt meter, ohmmeter, or other instrument. Personal computers are being used in data acquisition with special data acquisition boards installed in the computer. These boards are inserted into the

chassis of the computer and allow it to be connected to external devices, such as sensors, probes and other monitoring devices. The computer provides many attractive features to the data acquisition like high clock speed, programming flexibility, mass data storage and etc. [1] So, Acquired data always can be displayed, analyzed, and stored on a computer, and using various general purpose programming languages such as BASIC, C, Java can be developed for custom displays and control. A specialized programming language used for data acquisition like the series of Visual Basic which offers a graphical programming environment optimized and built-in graphical tools and libraries for data acquisition, representation and analysis.

A data acquisition system is a device designed to measure and logs some required parameters. To set up a data-acquisition system, the user should know exactly the characteristics of the desired system, in order to choose the right components in a discerning way. It is commonly accepted that essential apparatus include analogue measurement acquisition tool, amplifier, filter, ADC and DAC, and some transmitting and receiving equipments.

1.2- Motivation and challenges

The communication via USB based without the need for an external power supply and allowing some devices to be used without requiring individual device drivers to be installed. Also, it allows devices to be connected and disconnected without restarting the computer. Therefore, as the improvement of USB, the communication becomes more and more conveniently and efficiently.

Human prefers to read or analyze the data information in an easier way like present the desired data graphically. And then the trace presented data may need to amplify, de-amplify or shift in order to obtain the expected effect.

Although the software development tool-Visual Basic 2005 easily designs great-looking and easy-to-use applications using an intuitive, drag-and-drop interface designer, it is still a new programming language hence VB for programming on PC should be a hard and challengeable work. The communication program between the PC based on virtual serial port and USB module is still a key issue.

1.3- Aim and objectives

Aim:

The aim of this project is to graphically present data acquired over the USB port.

Objectives:

1. Develop the ActiveX control component for the graphical representation of data.
2. Develop the required graphical interface to simulate oscilloscope for presenting the graphical data to the user.
3. Develop the communication backchannel for acquiring data from the USB module.

1.4- System description

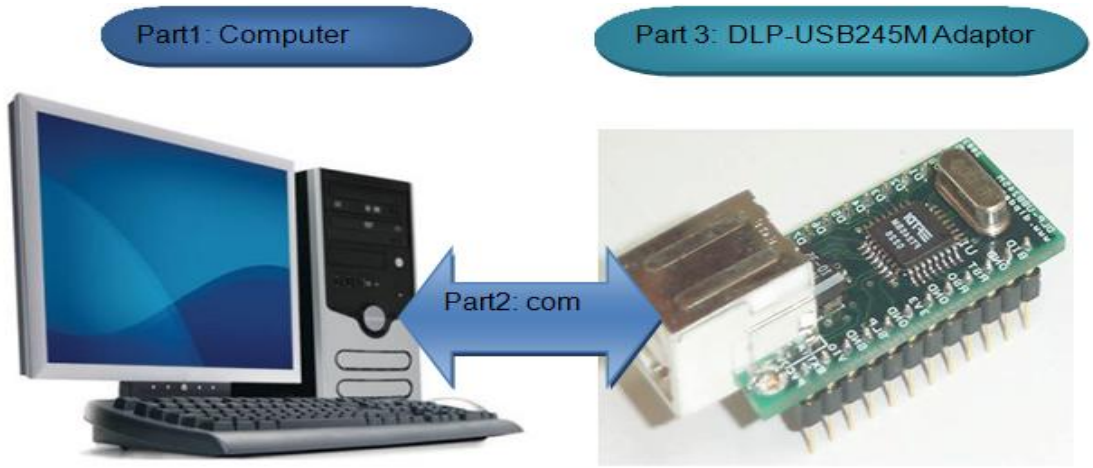


Figure 1 Project System

Figure 1 simply indicates desired system that how to undertake the data exchange between the PC and USB. In Part 1, the PC is used to install received data and then the GUI window will be designed to present data in an intuitionistic way by using VB. In part 2, the drivers will be developed to convert data information from RS-232 to USB and then complete the communication between the two components. In part 3, USB setting up and the pins' connections for powered configuration will be fulfilled. To sum up, this expected system is composed of software development and hardware configuration to realize graphical representation desired data.

1.5- Costing

Anticipated project costs were generated to ensure that project objectives could be met within the budget. The initial cost analysis is displayed in Table 1 below:

Equipments	Estimated cost	Remarks
PC	Resource provided by UH	
Visual Studio 2005 Software Package	Download from website: http://fsc.feis.herts.ac.uk/	Software needed for system implementation and testing
USB cable (Type A & B)	Around £3 (also available in Final year project lab)	Hardware accessories needed for connecting USB adapter
Bread-board	Resource available in lab	
RS-232 Cable	Resource provided by Mr. John Wilmot	Used for testing VCP
DLP-USB 245 User manual	Resource provided by Georgios Pissanidis	
USB drivers	Download from website: http://www.dlpdesign.com	

Table 1 Cost analysis

1.6- Report outline

- Chapter 1: according to literature research, this chapter concentrates on the related basic theory including the graphics operation and fundamentals and performance of USB module and RS-232 cable.
- Chapter 2: Based on the discussion of chapter 1, it emphasis on the development of software design for instance how to plot data and how to simulate oscilloscope's functions which are primary work in this project. The hardware actualization like testing serial port and USB port installation is involved as well.
- Chapter 3: The testing and simulation results associated with error analysis are presented in this chapter.
- Chapter 4: The problem and shortcomings have not resolved the improvements of the project and the difficulties in the procedure are stated. Also, main progresses are mentioned. Finally, the previous work is concluded briefly as well.

Summary

For what has been discussed above, a generic introduction on this subject including background information, aim and objectives, the details of cost analysis, and system description have been introduced. The following section is a review of the history and background plus the present state of knowledge of the subject area of the project work.

2. Subject Review

PC-based oscilloscope (PCO)

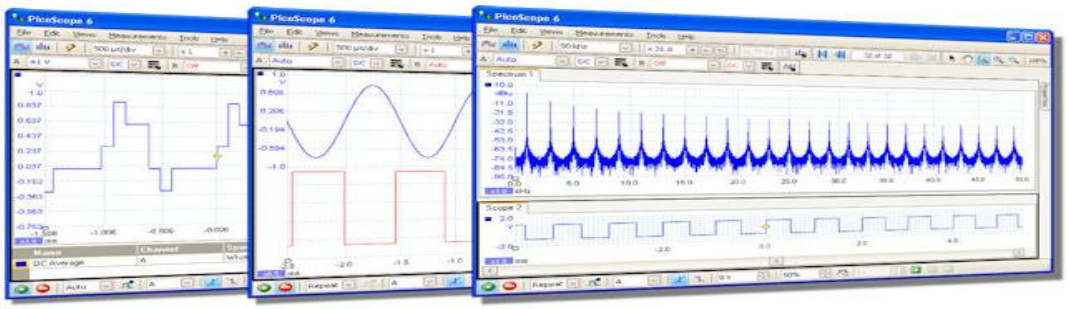


Figure 2 Pico Oscilloscope [14]

Although most people think of an oscilloscope as a self-contained instrument in a box, a new type of "oscilloscope" is emerging that consists of a specialized signal acquisition board (which can be an external USB or Parallel port device or an internal add-on PCI or ISA card). PC Oscilloscopes (PCOs) are rapidly replacing traditional digital storage oscilloscopes (DSOs) as the essential item for custom test equipment arsenal. The major advantages of PCO are that the display of a traditional oscilloscope is limited by the physical size of the oscilloscope, and may only be a single colour. With a PC Oscilloscope computer controls the display, so not only do user get a full colour display, but the display can be the size of user's monitor, projector or plasma display. Also, PC's typically have larger and higher resolution colour displays which can be easier to read. Colour can be utilized to differentiate waveforms. And USB 2.0 can transfer data at speeds of up to 480 Mbit/s. Using USB 2.0 PC Oscilloscopes give user incredible performance with fast screen updates and the ability to stream data. Furthermore, it can be used for data acquisition. [12]

Depending on PCOs' capabilities, the prices range from as little as $100 to $2000 therefore it suits for different customs' incomes and needs.

Nowadays, that Pico is the market leader in PC – the modern alternative to traditional bench-top oscilloscopes. Such as PicoScope 2200 Ultra-Compact USB Oscilloscopes is powerful yet easy to operate. Users benefit from the power of the PC, and the familiar Windows interface and controls, making the software easy to learn and easy to use on a daily basis. Drivers and examples are included for LabVIEW, C/C++, Delphi and Visual Basic for integration into custom applications. [14]

3. Description of project work

Chapter 1: Technical theory

Chapter overview:

The background information, the aim and objectives and the structure of the report were already indicated. In this chapter, the essential information and theory for carrying out the project is composed of the methods of plotting using Visual Basic language and the general description of USB port specifics on DLP-USB245M User Manual and RS-232 cable.

1.1 Software part: graphics and drawing functionality

1.1.1 Windows in the Visual Studio 2005 IDE

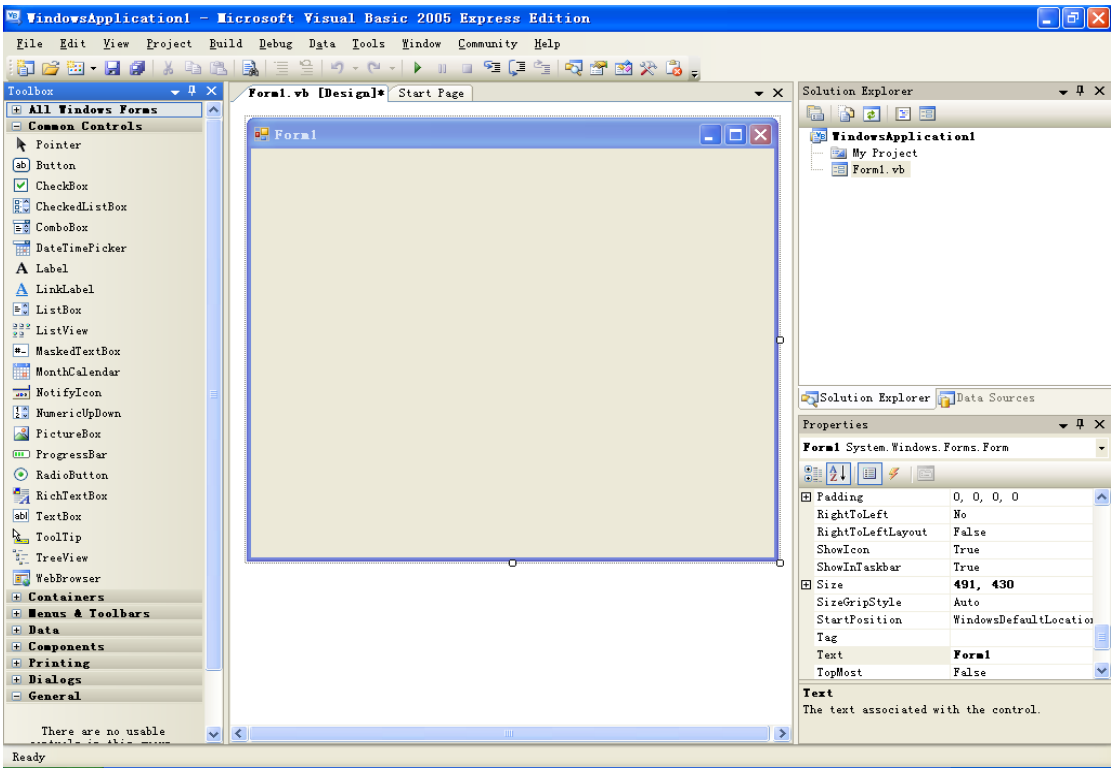


Figure 3 Windows in VB 2005 [3]

Toolbox: the toolbox contains reusable controls and components that can be added to the user's application. These can range from buttons to data connectors to customized controls.

Design window: the design window is where a lot of the actions take place. This is where developer will draw user interface on the forms. This window is sometimes referred to the designer.

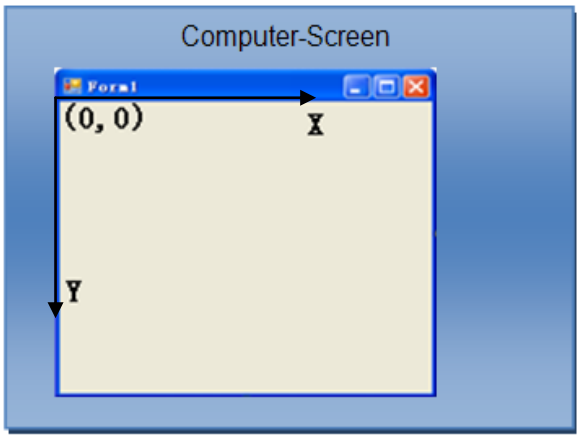
Solution explorer: this window contains a hierarchical view of developer's solution. A solution can contain many projects, whereas a project contains forms, classes, modules, and components that solve a particular problem

Properties: the window shows what properties the selected object makes available. [3]

1.1.2 The coordinate system of Visual Basic 2005

When Microsoft first released Visual Basic 1.0 it made building the user interface components of an application very simple. Instead of having to write thousands of lines of code to display windows- the very staple of a windows application known as a form that provides a platform for drawing line, shape or text on the screen. And the computer screen is made up of pixels. They are very small, but when working together they make a display on the screen. Since pixels on any given display are always of a uniform size, they are the common unit of measurement used in computer graphics. Often, the computer screen is set to 1,024 pixels across and 768 pixels down.

In Visual Basic 6.0, coordinates for forms and controls are expressed in twips while in Visual Basic 2005, coordinates are expressed in pixels so that the base currency of drawing is the pixel this means when the mouse is asked for its position, a set of coordinates given in pixels should be got back. In VB 2005, if the user clicks the mouse in the very top left pixel, the coordinates of (0, 0) will be shown and the user clicks in the very bottom right pixel, the coordinates of (1024, 768) will be got back. However, every window has a client area, which is the area the programmer can use to report the program's output. When the lines or shapes are drawn onto the control or form, the user always dealing with this client area. The coordinates used when drawing are adjusted so that the position of the window itself on the screen becomes irrelevant. These coordinates are known as client coordinates. [3]



For example, there are actually two different coordinates should be got for the top-left corner of the Form1 paint area.

- Around (350,330) is the screen coordinates, also known as the absolute position.
- Around (0, 0) irrespective of where the window is positioned on the screen and this is the adjusted client coordinates, known as relative position. [3]

Figure 4 Coordinate System

1.1.3 Graphics operation

The graphics class provides methods for drawing objects to the display device. A graphics is associated with a specific device context and many different shapes and lines by using a graphics object can be drawn. Before drawing the lines and shapes, render text, or display and manipulate image, a graphics object that represents a GDI+ drawing surface should be created. [4] Therefore, there are two steps in working with graphics:

- Creating a graphics object

A graphics object can be created in a variety of ways:

- Receive a reference to a graphics object as part of the PaintEventArgs in the Paint event of a form or control. This is usually how the user obtains a reference to a graphics object when creating painting code for a control.

-Or-

- Call the 'CreateGraphics' method of a control or form to obtain a reference to a Graphics object that represents the drawing surface of that control or form. Use this method if the user wants to draw on a form or control that already exists. [4]

- After a graphics object was created, using it to draw lines and shapes, render text, or display and manipulate images.

- Draw line: Draws a line connecting the two points specified by the coordinate pairs. The common form is like Graphics. DrawLine Method (Pen, Point1, Point2) where the parameters are described in table below:

Parameter name	Type	Function
Pen	System.Drawing.Pen	Determines the color, width and style of the line
Point1	System.Drawing.Point	Point structure that represents the first point to connect
Point2	System.Drawing.Point	Point structure that represents the second point to connect

Table 2 DrawLine Method [5]

Upon the description above how to draw line can be summed as

- Creates a pen
- Creates points for the endpoints of the line.
- Draws the line to the screen.[5]

- Draw text: the common method is like Graphics. DrawString Method (String, Font, Brush, PointF) draws the specified text string at the specified

location with the specified Brush and Font objects. The parameters description in the following table:

Parameter name	type	Function
string	System.string that Represents text as a series of Unicode characters.	String to draw
font	System.drawing.font this class cannot be inherited.	Defines a particular format for text, including font face, size, and style attributes.
brush	System.drawing.brush	Determines the color and texture of the drawn text
Point	System.drawing.pointF Represents an ordered pair of floating-point x- and y-coordinates that defines a point in a two-dimensional plane.	PointF structure that specifies the upper-left corner of the drawn text.

Table 3 DrawString method [6]

- Creates a text string to draw.
- Defines the font as Arial (16pt).
- Creates a brush to draw with.
- Creates a point for the upper-left corner at which to draw the text.
- Draws the string to the screen using the font, brush, and destination point. [6]

Oftentimes, a Graphics object is obtained by handling a control's Control. Paint event and accessing the Graphics property of the System.Windows.Forms.PaintEventArgs class. The Paint event is raised when the control is redrawn. It passes an instance of PaintEventArgs to the method(s) that handles the Paint event. When programming the PaintEventHandler for controls, a graphics object is provided as one of the PaintEventArgs. [4]

To obtain a reference to a Graphics object from the PaintEventArgs in the Paint event:
1. Declare the Graphics object.
2. Assign the variable to refer to the Graphics object passed as part of the PaintEventArgs.
3. Insert code to paint the form or control. [4]

1.1.4 ActiveX control

The history of Windows Forms Controls has roots in something known as controls Visual Basic Extension (VBX). This later became more widely known as ActiveX, and today, revitalized and reborn into the .NET Framework, it is known as Windows Forms controls. There are several good reasons for wanting to create Windows Forms Controls. Firstly, the same control throughout an application or in lot of different applications can be reusable thus saving on code and the code relating to a control within the control's class can kept for making the code cleaner and easier to understand. [3]

A user control is implemented as a class. Therefore, anything can be achieved with a class, it should be also done with a user control that means the user can add properties, methods, and events to the user control that can be manipulated by whoever is consuming it. The user control can have two sorts of properties: those that can be manipulated from the properties window at design time and those that have to be programmatically manipulated at run time. Hence, in certain circumstances, it is useful to know whether the user control is in design mode or run mode. The control is in design mode is when a form is being designed and the properties of the control are being set; it is in run mode when the form is being run and the control is able to expose methods and events. For example, it is not be appropriate for the control to plot data when the form is being designed, but the user will want it to when the application is being run. Usually, a control itself has a Boolean property called DesignMode which returns true if the control is in design mode and False if it is not. [3]

1.2 Communication between software and hardware

1.2.1 The PC's Serial Port & Virtual serial port in VB 2005

All PCs have at least one serial communication port. Serial ports have been a part of the PC from the beginning. Each COM, or Comm, (communications) port in a PC is an asynchronous serial port controlled by a UART. A COM port may have the conventional RS-232 interface, or the port may be dedicated for use by an internal modem or other device. A PC may have other types of serial ports as well such as USB, Firewire, but these use different protocols and require different components. Each serial port in a PC reserves a set of port addresses, and most also have an assigned interrupt-request (IRQ) line, or level. The ports are designated COM1, COM2, and so on up together with some properties like BaudRate, BitRate and etc. [7]

As for VB2005, it has a control-SerialPort for serial Communication similarly the Mscomm control in VB6.0. Encapsulation some useful properties (BaudRate, DataBit, Parity, Encodings….), methods (close, read, write, open…) and events (DataReceived, ErrorReceived...) as SerialPort class and the programming application base on this virtual serial port. Use this class to control a serial port file resource. This class provides synchronous and event-driven I/O, access to pin and break states, and access to serial driver

properties. [8] The SerialPort VB2005 supported is a communication link between software and external devices.

1.2.2 Buffers

Buffers are another way that receivers can ensure that they do not miss any data sent to them. Buffers can also be useful on the transmit side, where they can enable applications to work more efficiently by storing data to be sent as the link is available. [7]

The buffers may be in hardware, software or both. The serial ports on all but the oldest PCs have 16-byte hardware buffers built into the UARTs. In the receive direction, this means that the UART can store up to 16 bytes before the software needs to read them. In transmit direction, the UART can store up to 16 bytes and the UART will take care of the details of transmitting the bytes bit by bit, according to the selected protocol. [7]

When the hardware buffers are not large enough, a PC may also use software buffers, which are programmable in size and may be as large as system memory permits. The port's software driver transfers data between the software and hardware buffers. [7] For this project, the transferring data must be stressed that in order to achieve maximum throughput, application programs should send or receive data using buffers and not individual characters.

1.3 Hardware introduction: RS-232 Cable & DLP-USB245M User Manual

1.3.1 Description of RS-232 cable

RS (Recommend Standard)-232 is one of the most popular computer interfaces of all time Specifies electrical, functional, procedural and mechanical aspects of the interface and is designed to handle communications between two devices with a distance limit of 50 to 100 feet depending on the bit rate and cable type. Its most common use is to connect to a modem, but other devices with RS-232 interfaces include printers, data-acquisition modules, test instruments, and control circuits. Sometimes, a simple link between computers of any type by using RS-232 can be achieved. Furthermore, the hardware and programming requirements for RS-232 are simple and inexpensive and because so many existing devices already have the interface built-in. An RS-232 link may use any of a number of connector type, pin configurations and combinations of signals. These days, most PCs use a 9-pin male D-sub connector for serial ports. These include only the nine signals. Used for connections between DTEs and voice-grade modems, and many other applications. The Figure 5 shows popular connectors used in RS-232 interfaces and the pinouts of the connectors. [7]

DB-9 Female (DCE) DB-9 Male (DTE)

RS-232 Pinout

RS-232 (EIA-232-A) Function	DB-25 pin #	DB-9 pin #
Shield	1	
Transmit Data (TD) from DTE to DCE	2	3
Receive Data (RD) from DCE to DTE	3	2
Request to Send (RTS)	4	7
Clear to Send (CTS)	5	8
DCE Ready (DSR)	6	6
Signal Ground (SG)	7	5
Received Line Signal Detector (DCD)	8	1
DTE Ready (DTR)	20	4
Ring Indicator	22	9

Figure 5 RS-232 D-sub connectors and pin locations for RS-232 connectors [9]

The device that connects to the interface is called a Data Communications Equipment (DCE) and the device to which it connects (e.g., the computer) is called a Data Terminal Equipment (DTE) which is a device that controls data flowing to or from a computer. In practical terms, the DCE is usually a modem or other RS-232 device being controlled by a computer and the DTE is the computer itself, or more precisely, the computer's UART chip. [9]

1.3.2 DLP-USB 245M User Manual

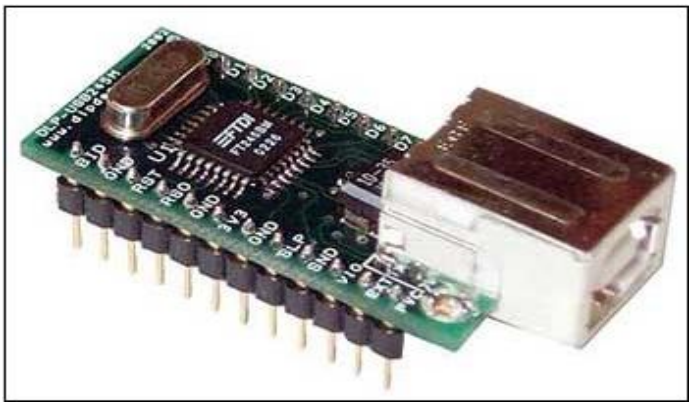


Figure 6 DLP-USB 245M User Manual [10]

The DLP-USB245M is the 2nd generation of DLP Design's USB adapter. This device adds extra functionality to its DLP-USB1 predecessor with a reduced component count and a new low price. It has several main features shown below [10]:

- Send/Receive Data over USB at up to 1M Bytes/sec
- 384 byte FIFO Transmit buffer /128 byte FIFO receive buffer for high data throughput
- Simple interface to CPU or MCU bus
- Protocol is handled automatically within module
- FTDI's Virtual COM port drivers eliminate the need for USB driver development in most cases
- Integrated Power-on-Reset Circuit
- USB VID, PID, serial number and product description
- Strings stored in on-board EEPROM
- EEPROM programming on-board via USB
- Virtual COM port (VCP) Drivers for windows 98/2000 and etc. [10]

The DLP-USB245M provides an easy cost-effective method of transferring data to/from a peripheral and a host at up to 8 million bits (1-Megabyte) per second. Its simple FIFO-like design makes it easy to interface to any microcontroller or microprocessor via IO ports.

To send data from the peripheral to the host computer simply write the byte wide data into the module when TXE# is low. If the (384 byte) transmit buffer fills up or is busy storing the previously written byte, TXE# is taken high by device in order to stop further data from being written until some of the FIFO data has been transferred over USB to the host. [10]

When the host sends data to the peripheral over USB, the device will take RXF# low to let the peripheral know that at least one byte of data is available. The peripheral then reads the data until RXF# goes high indicating no more data is available to read. By using FTDI's virtual COM Port drivers, peripheral looks like a standard COM Port to the application software. [10]

As for hardware accessories-USB cable & Bread-Board, which are used for installing USB adapter within Appendix C.

Summary

This chapter introduced the concept and methods of relative theory ready for developing software design such as how to draw lines and draw text using VB2005. Also, the fundamental information on hardware devices was presented. After that, the following chapter will introduce the practical work development for this project based on the theory mentioned above.

Chapter 2: Project development and implementation

Chapter overview

The coordinate system, the method of draw-line and draw text and the features of the RS-232 cable and USB port have discussed above. In this chapter, the project design, the flowchart instead of source code for describing the implementation of this subject together with some explanations, the serial port test by using RS-232 cable and the installation of USB module will discuss in detail.

2.1 Project overview and design

2.1.1 Project overview

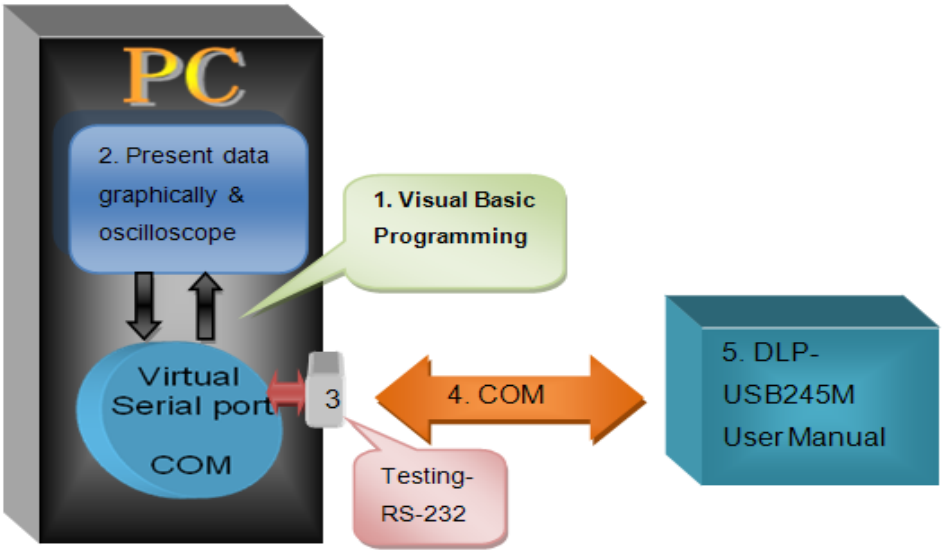


Figure 7 Project overview

In the communication world, there is always a need to evaluate data it is preferable for them to be presented in a graphical format. In order to carry out this aim the subject can be splitted into five steps as shown as Figure 7. This project should focus on developing software. At the beginning, a user interface to plot data graphically and adjust the trace presented data in some ways was built using Windows Forms in the Windows applications and then changed to create the custom controls known as ActiveX control which is so useful is that they are reusable. It was Visual Basic programming language that supported main work. When it comes to step5, USB installation would be done after the communication programme was ready for receiving data. In the following sections, these five steps will be gone into particulars.

2.1.2 Project design

The programming language chosen for the development of software code was Visual Basic 2005 that was a part of Visual Studio 2005. The reason for this based around the advantages that VB changed the fact of Windows programming by removing the complex burden of writing code for the user interface (UI). By allowing programmers to draw their own UI, it freed them to concentrate on the business problems they were trying to solve. Once the UI is drawn, the programmer can then add the code to react to events. [3]

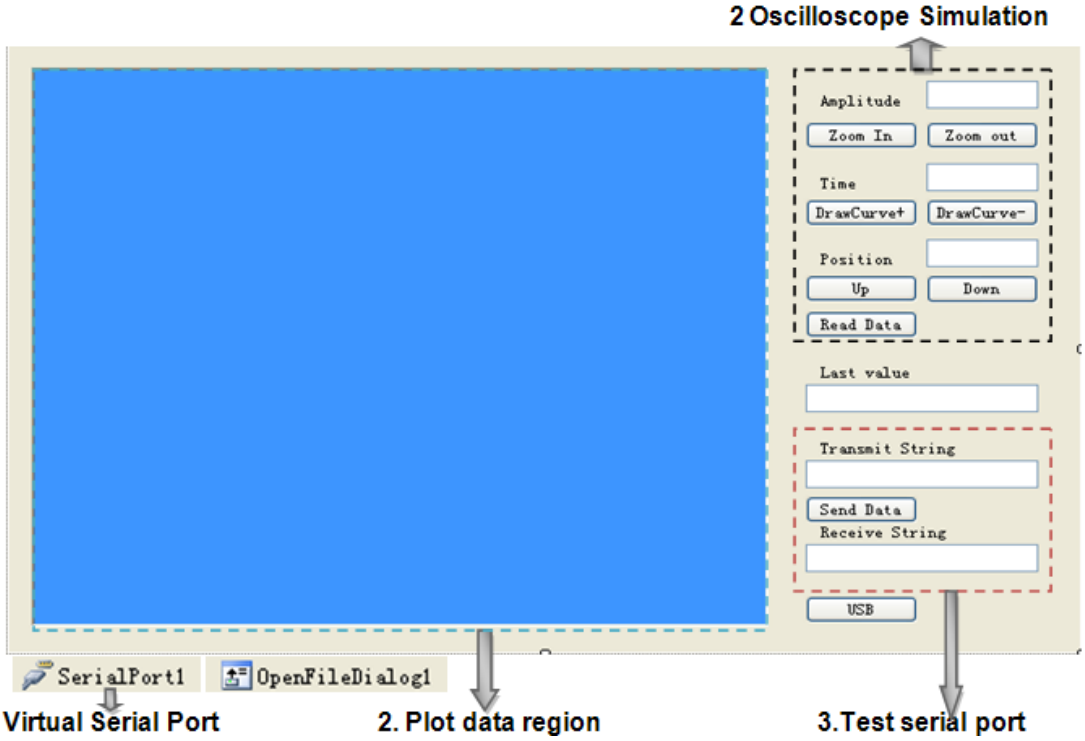


Figure 8 User interface for plotting data

To build a form or a control, the controls under the Tool-Box are painted onto a blank window called Forms Designer using the mouse. Each of these controls is able to tell the user when an event happens. The window as shown above is called “Usercontrol1” by default.

According to Figure 8, the blue colour area for plotting data using the panel control named “PicDataView” which is a control that contains other controls. It is similar with canvas that can be used to group collections of controls. If the Panel control's Enabled property is set to false, the controls contained within the Panel will also be disabled.

On the top of the right side, several controls were designed to undertake the oscilloscope simulation including labels-provides run-time information or descriptive text for a control, Buttons-Raises an event when the user click it and texts-enable the user to enter text, and provides multiline editing and password character masking. [3] For example the amplitude of the track shown on the left will be zoomed in or zoomed out when the user click the corresponding buttons. Hence, the three text controls are for showing value of changeable

amplitude, time and position and the six buttons are used to control or adjust these events occurred. The rest part in this figure is for carrying out testing. The two text boxes are for display the transmission data and receiving data with the button named send data to control the event happened. Adding another two labels is to describe the controls. On the middle of the right side, the text box is designed to display the value of last received data.

On the bottom of the user interface, the serial port control selected which is utilized to undertake the communication channel with the USB module as step 4 shown in Figure 7 and the other control called OpenFileDialog in case of the windows applications process data from file therefore an interface is needed to select files to open and save. The .NET Framework provides the OpenFileDialog & SaveFileDialog classes to do just that. Furthermore, the USB button on the bottom of right side consists of the serial port settings and the programming for communication so that another interface was designed:

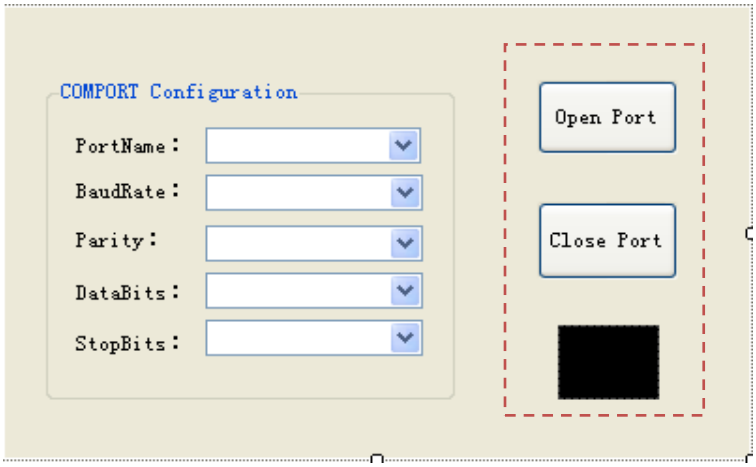


Figure 9 Serial Port setting

The configuration of serial port such as BaudRate, Parity, DataBits and StopBits was implemented in this interface and on the right the buttons named “open port” & “close port” were chosen for controlling the COM port in PCs which was an essential tool for testing serial port due to different computers often have different COM ports. With this part should make the system work more conveniently and perfect. The black colour component is regarded as a sign to indicate the status of the serial port. When the light becomes to red means the port is close and the green shown the port is open.

Alternatively, from windows 95, it allow the serial port setting to be set by selecting my computer→ properties→Device Manger→Ports (COM and LPT)→Port Settings.

After developing the ActiveX control component for plotting data, it still needs an interface as a platform using the form to execute the function of the existent control called ‘UserControl1’ by default.

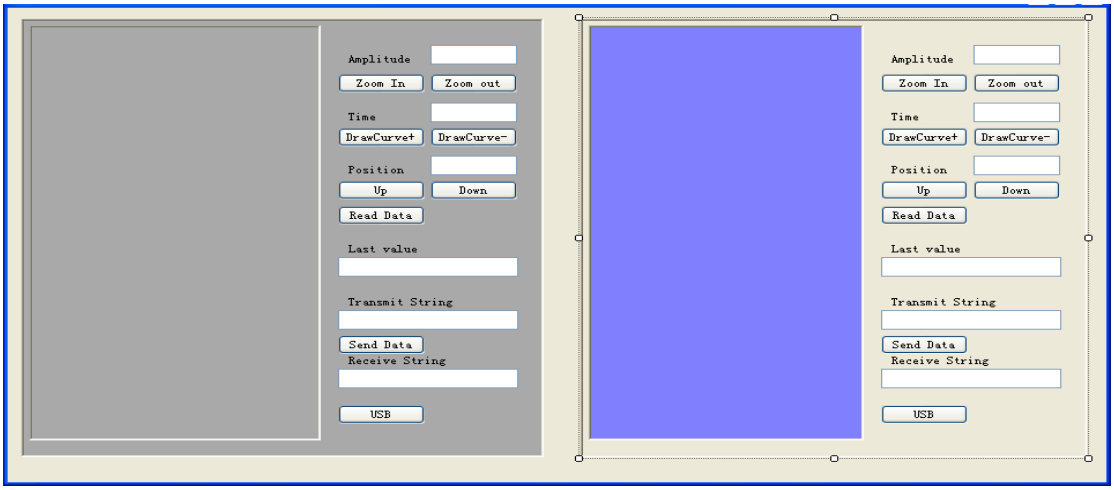


Figure 10 Run interface

Sometimes, more than one user-control is added into this interface called “usercontrol11” and “usercontrol12” by default to carry out specific task that provides a simple way to contrast and analyze among different curves. Similarly, the 'Dual trace' oscilloscopes display two *V/t* graphs at the same time, so that simultaneous signals from different parts of an electronic system can be compared. In addition, this interface can be shown to the user in practical work unlike the ActiveX control before that is just for the designer.

When it comes to the USB port installation, the USB adapter should be inserted into the bread-board ready for the pin# connections. Then USB port is connected to the PC via a standard, 6-foot USB cable.

2.2 Project implementation

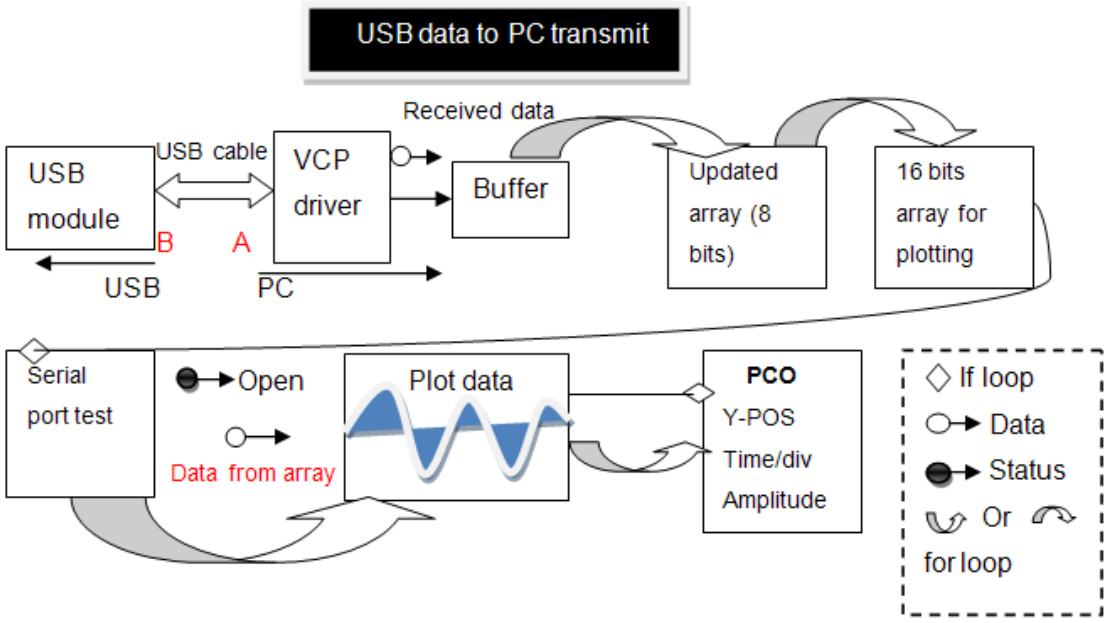


Figure 11 Program structure diagram

2.2.1 Software development

Building a user interface using Windows Forms or Windows Controls is all about responding to events, so programming for Windows opened up the world of event-driven programming. Events in this context include, for example, clicking a button, resizing a window, or changing an entry in a text box. The code that the programmers write responds to these events.

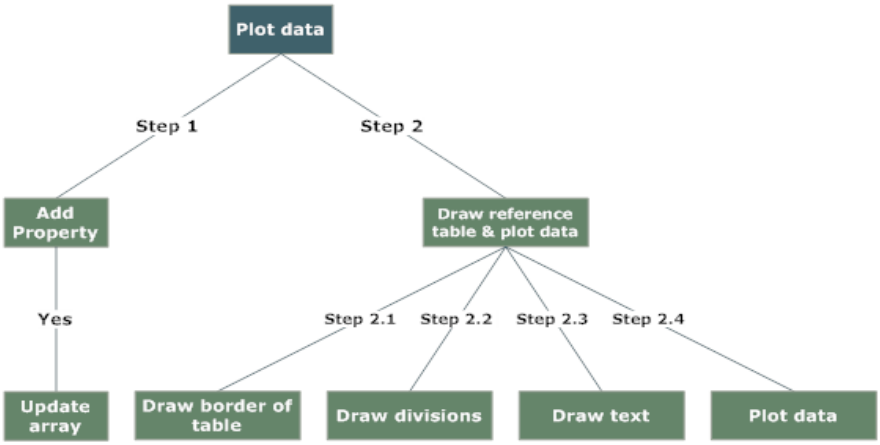


Figure 12 Structure for plotting data

The key task for software development is on plotting data. First of all, adding a new property to the control is necessary to tell the control when to plot data instead of the globe variable due to some ineluctable confusion always happened when debugging software.Moreover, that is a fairly common requirement in writing software is the ability to hold lists of related data. This functionality can be provided by using an array and it is just lists of data that have a single data type. When data is coming, the array should be ready for receiving the data and updating simultaneously owing to the received data is different. From Figure 12, four sub-steps come under the step2 which are main embranchments for completing to draw the track representation of desired data with reference table or screen in oscilloscope to measure the trace onto the canvas-the blue colour part(Figure 8). Next, the flow charts will introduce how to realize to plot data graphically step by step based on Figure 12.

Step1: Add new Property & Update the array

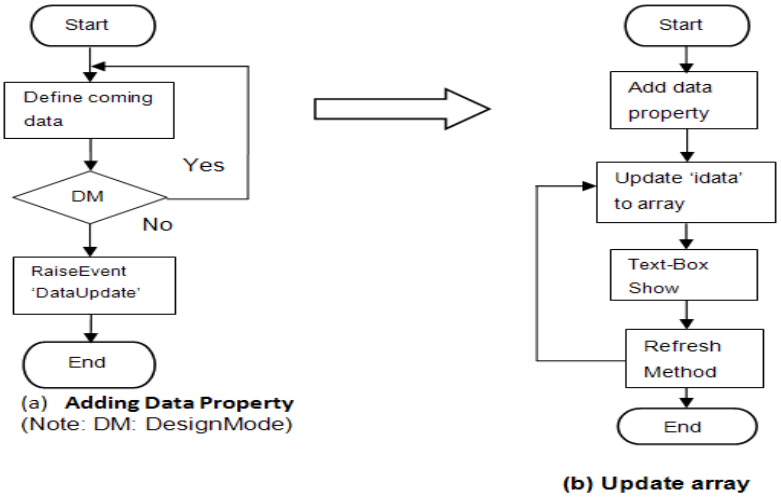


Figure 13 Step 1: Update array

To add a new property called “data”, a member variable-“idata” should be declared in the public class loop as integer for storing a value. When the value is changed, it will call into the object and set the property. When the property is set, the text in the private member that was just defined needs to be set as well. After that, the new property will be exposed when the project is built.

The explanation on Figure 13 (a)

- **Define coming data**: a variable-“idata” working through the algorithm for the coming data is declared that can be passed to the default value of an empty integer for the data property.
- **DesignMode**: if the property is a fairly simple type such as String, Integer, or Boolean and does not have parameters, it can be manipulated at design mode. If the property is a complex object, such as a database or file connection, or if it has parameter, it should be carried out at run time. [3] Obviously, this property has a parameter and the ‘DataUpdate’ event should be active at run mode, hence, at run time the property is manipulated and raise the event named ‘DataUpdate’.
- **RaiseEvent: ‘DataUpdate’**: the user own events from the control named ‘DataUpdate’ should be exposed that is allowed the custom who use this control to take action in their code when the event is raised. Defining the ‘DataUpdate’ event is as simple as adding an Event statement, the event name, the parameters that the event will return. In this case, the new event-‘DataUpdate’ is performed to updating the array to store the “idata”. To raise an event, the RaiseEvent statement needs to be specified, the event name-‘DataUpdate’ as well as the parameters for the event being raised should be passed to it together.

The exposition on Figure 13 (b):

- **Update ‘idata’ to array**: The array ready for plotting called m_DataPlot (1000) is defined as integer in the Public Class loop and 1000 means 1000 locations for holding data. Therefore, the received data need to be taken into this data array. The ‘m_DataPlot’ array should allocate room to hold “idata” as the Figure 14 shown. To realize this function, the counter named ‘iDataCounter’ was defined as a variable to alter and control the length of the ‘m_DataPlot’ array. After several cycles, the location of m_DataPlot (0) would be empty for storing the received data-“idata”.

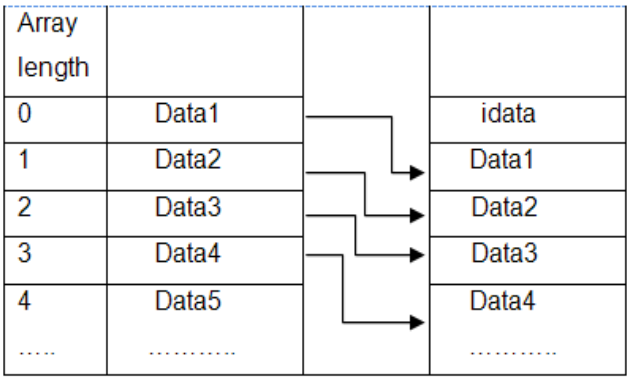


Figure 14 Update Array explanation

✧ **Text-Box show**: from Figure 8 the design interface, on the middle of right side the text control is designed to display the last value-'idata' to the user. In that case, the user can be aware of the value of received data.

✧ **Refresh method**: refreshes the content of the table. This might be necessary after a call to a method when the page does not automatically reflow.

Step 2: Draw reference table & plot data

This step is divided into four sub-steps those are step 2.1 draw the border of region for plotting or reference table, step 2.2 draw the divisions used to measure the curve like the background screen of oscilloscope, step 2.3 draw texts for showing value and step 2.4 plot data using sine math function.

Figure 15 (a) step 2.1 Draw the border (b) step 2.2 Draw divisions (c) step 2.4 Plot data

The description on Figure 15 (a):

The function of a real oscilloscope is extremely simple: it draws a *V/t* graph, a graph of voltage against time, voltage on the vertical or Y-axis, and time on the horizontal or X-axis. As shown as Figure 16 (left), the screen of this oscilloscope has 8 squares or divisions on the vertical axis, and 10 squares or divisions on the horizontal axis. Usually, these squares are 1 cm in each direction. [11]

- ✧ **Create graphics object "gr"**: when to draw line, text or shape, a graphics object named "gr" represents a GDI+ drawing surface should be created first by using to call the 'CreateGraphics' method of a control or form to obtain a reference to a Graphics object.
- ✧ **Define four points**: the border of region was designed as a rectangle that was composed of two pairs of height and width consequently the four coordinates points need to be defined at the proper position according to the screen-"PicDataView" shown as below:

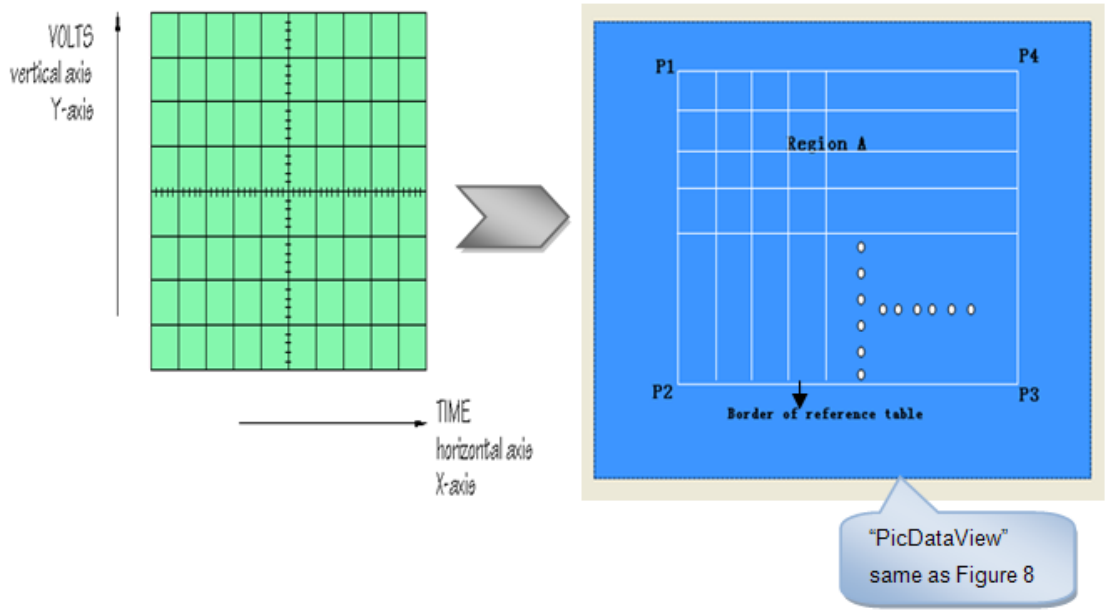


Figure 16 Real oscilloscope screen (left) vs stimulant oscilloscope screen (right)

For example, the width and height of "PicDataView" can be found like:

m_endY=PicDataView.height & m_endX=PicDataView.width

Therefore the coordinate of P1 may be defined as (70, 5), P2 (70, m_endY-20), P3 (m_endX-10, m_endY-20) and P4 (m_endX-10, 5).

- ✧ **Draw the border of table**: four lines connecting every two points specified by the coordinates by using gr. Drawline (Pen, Point1, Point2) format can be drawn where the "pen" is chosen to determine color or style of the line.

The explanation on Figure 15 (b):

- ➢ **Define the range of reference table:** For what has been discussed above, the reference table was designed as rectangular so that height and width can be utilized to determine the range of it. On account of this, the range of reference table:

Height=P2Y-P1Y = m_endY - m_startY - 25

Likewise: width = m_endX - m_startX – 80 where the m_startY and m_startX are defined as 0 initially.

✧ **Divide the plotting region by 10**: from Figure 16, the 'region A' was framed to be separated into 10 squares or divisions on the vertical axis, and 10 squares or divisions on the horizontal axis. Such as:
m_Vnum=height/10 & m_Hnum=width/10 where the m_Vnum and m_Hnum figure every divisions of the screen which is prepared for next step.

✧ **Draw lines from left to right & from top to bottom**: two "for" loops and the gr. Drawline method to carry out this step is the best way. On this condition, the key is about using a variable along with the m_Vnum or m_Hum to draw lines at different positions. When the lines are drawn from left to right, the variable multiplies the m_Vnum that means adding a distance of square towards y axis every time, the "pen" will draw a line. As time goes by, when the 9 cycles of loop complete, nine lines will appear in the horizontal direction of region A. Then the same way to draw lines from top to bottom but the variable should multiply the m_Hnum that describes the "pen" will draw a line as adding a distance of square towards x axis shown as Figure 16(right).

The further description on Figure 15 (c):

✧ **Define offset**: the globe variable 'offset' is defined to use for vertical midpoint that ensure the track representation of data is drawn from the middle of the reference table. Ideally, it should be calculated as the height of "PicDataView" minus the half of height of reference table. This variable is so useful that will discuss in detail in the following section.

✧ **Calculate every step of "x" axis-dx**: the resolution of x axis or the step of x will be used in the "plot data" part. It depends on the width of reference table and the length of array hold the data. Therefore, it is defined as:

dx = width/ m_DataPlot.lenght-1 sometimes it is called scaling.

Where width = m_endX - m_startX – 80 and 'm_DataPlot' is the array ready for plotting both of them have been already introduced above.

✧ **Call "range_change ()" subroutine**: the subroutine called "range_change()" is the scaling of y axis or the resolution of between unit pixel in the region of window display that will be added in the "plot data" part as well. This part consists of a sub-flowchart will be described minutely below.

✧ **Plot data**: after the data acquiring over the USB module and then storing in the 'm_DataPot' array, it should be plotted onto the reference table graphically by using the sine math function. This section includes several sub-flowcharts which will be discussed in the following part.

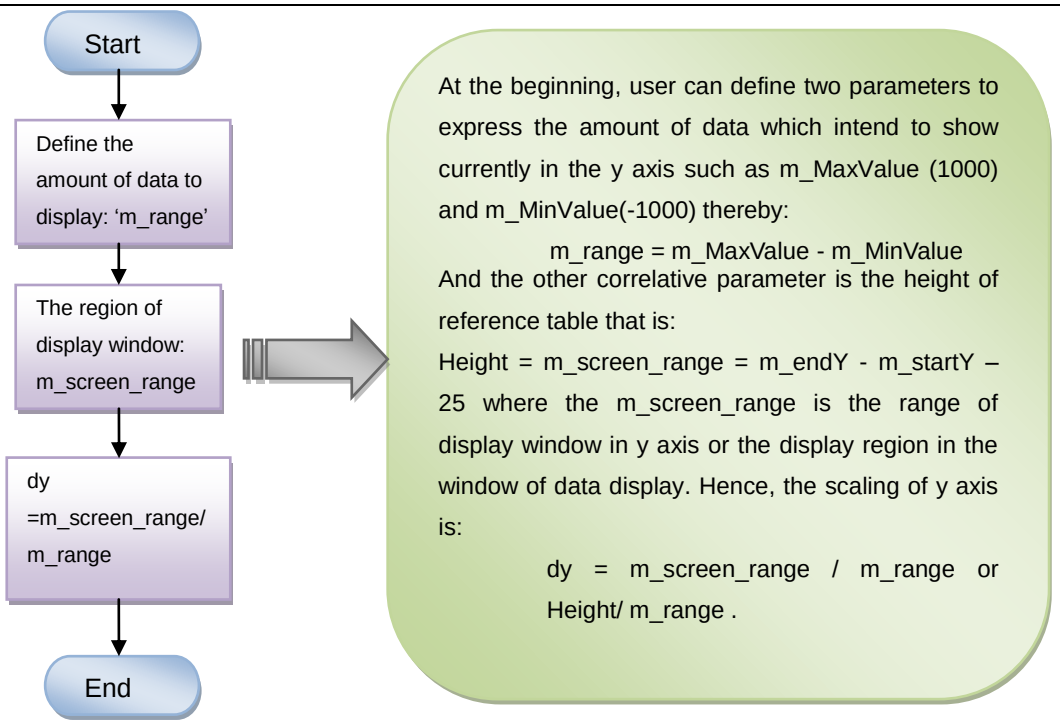


Figure 17 Sub-flowchart of step 2.4 A) - Call "range_change ()" subroutine

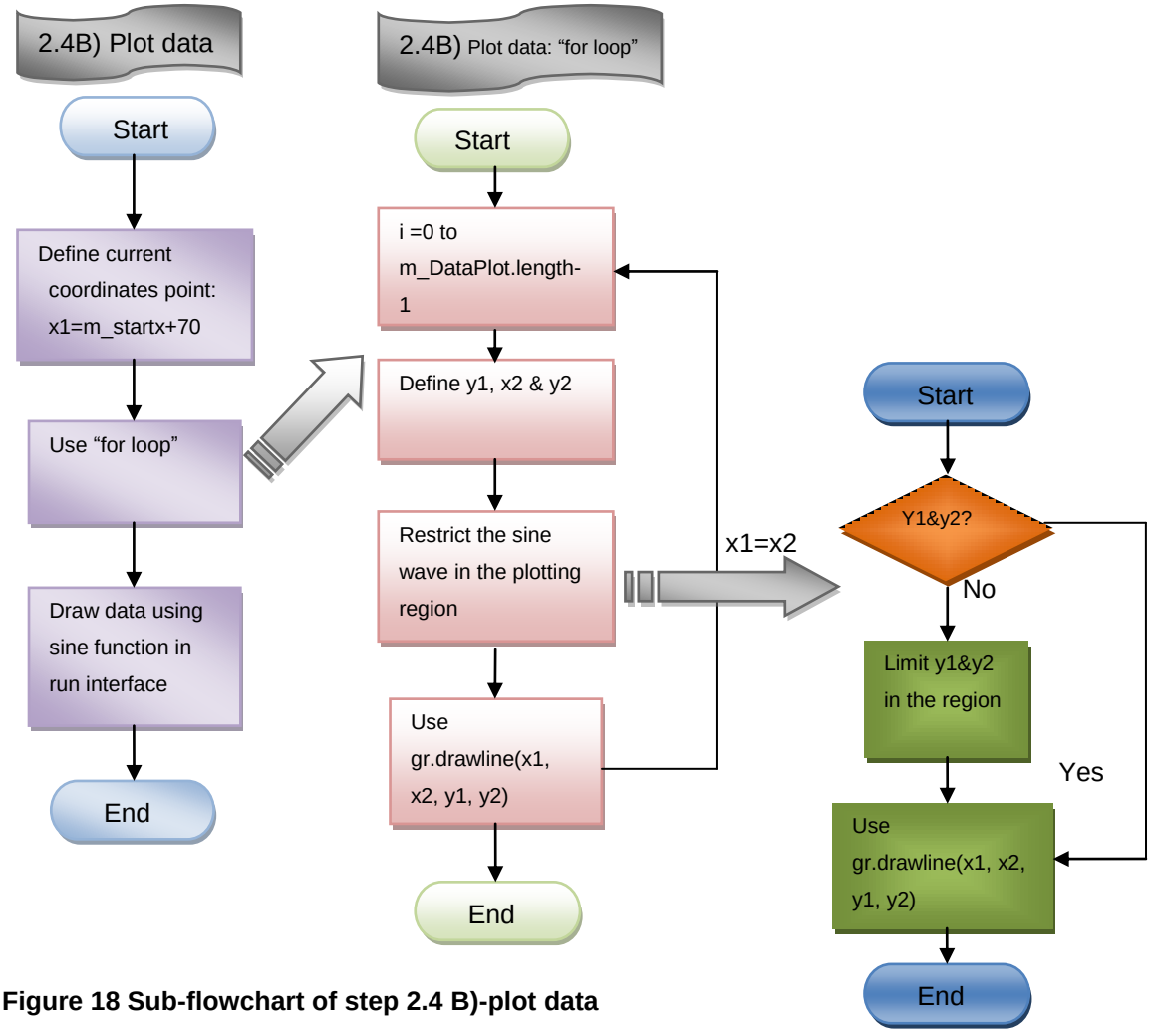


Figure 18 Sub-flowchart of step 2.4 B)-plot data

The explanation on 2.4 B) plot data in Figure 18:

There are three primary steps for plotting data. First of all, the x-dimension(x1) of the current coordinates point should be defined outside the 'for' loop. Secondly, using 'for' loop is to realize the circle for drawing sine wave. Besides, at the Form Designer for "plotting data" (Figure 10), the data should be plotted.

The exposition on 2.4 B) plot data: "for" loop:

- **i=0 to m_DataPlot.length -1:** the "i" is defined as a counter and adding 1 as the loop cycles every time so that it can be utilized to execute together with the y-dimension (y1) of the current coordinates point and the following coordinates point (x2, y2) owing to the distance or displacement of x axis and y axis should increase automatically along with the length of 'm_DataPlot' array increases for drawing sine track. Moreover, the "i" is the parameter of 'm_DataPlot', thus, the m_DataPlot (i) describe the needed data not the address.

- **Define y1, x2 & y2**: on this condition, the "offset", "dx", "dy" were introduced above should be performed together with these variable. The y-dimension of the current point is calculated ideally :

$$y1 = offset - m\_DataPlot(i) * dy$$

But in the practical debugging, some unknown problem occurred, if the y1 was defined as above shown, the track would always turn over that would discuss in the following chapter. Accordingly, the y1 is corrected to

$$y1 = offset + m\_DataPlot(i) * dy$$

Likewise, the next coordinates is defined as

$$x2 = 71 + i * dx \quad (x1=70)$$

$$y2 = offset + m\_DataPlot(i + 1) * dy$$

The "offset" is to assure the begging point is at the middle of the reference table so all coordinates points are plotted according to the "offset". If the "offset" changes, the position of the curve will be altered as well. By multiplying the "dx" and "dy", the sine-curve can be zoomed in and zoomed out automatically as the size of screen changes. Assuming the "dx" or "dy" are not used the curve will be only straight line in the x axis or y axis.

- **Restrict the sine wave in the plotting region** (note: Y1&y2 stands for y1&y2 belong to the plot region):

When the sine wave is zoomed in, the trace may be beyond the reference table therefore 'if' statement should be used to test the conditions about the value of y1 and y2. If both of them are in the region of reference table, the statement of drawing line will be executed directly. On the contrary, they should be forced to the maximum value of y1 and y2 and then the next statement will be performed as well.

✧ **Using gr. drawline (x1, y1, x2, y2)**: hundreds or thousands of related coordinates points or data come into being a track like sine wave. And in order to plot data by using sine function, the points in the coordinates system have to be moved forward through some track. Accordingly, the x1 should be forced to x2 and then the loop will be back to the start that drives the loop continues to cycle until all the data hold in the 'm_DataPlot' array is drawn out.

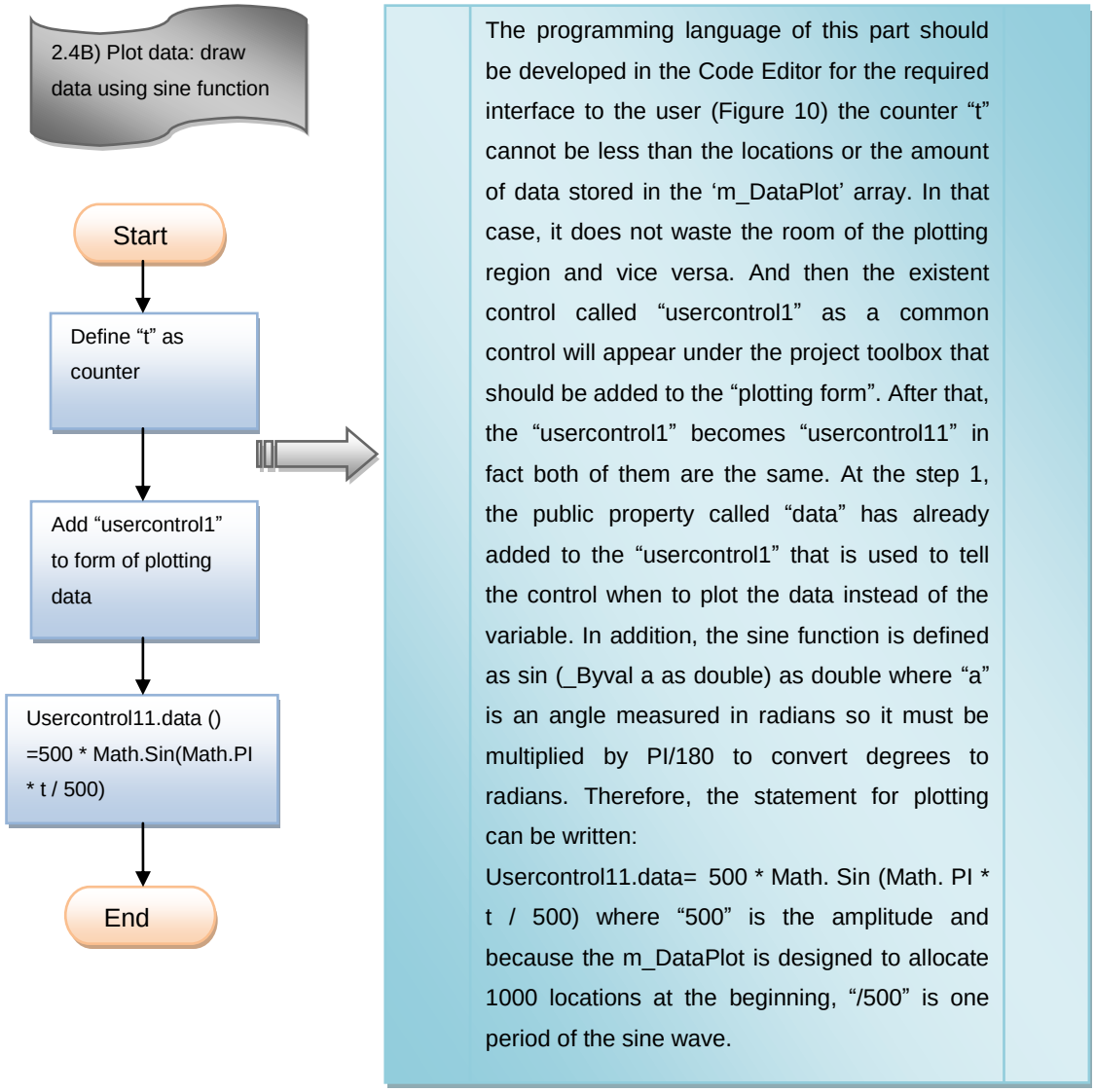


Figure 19 Sub-flowchart of step 2.4 B) Plot data: draw data using sine function

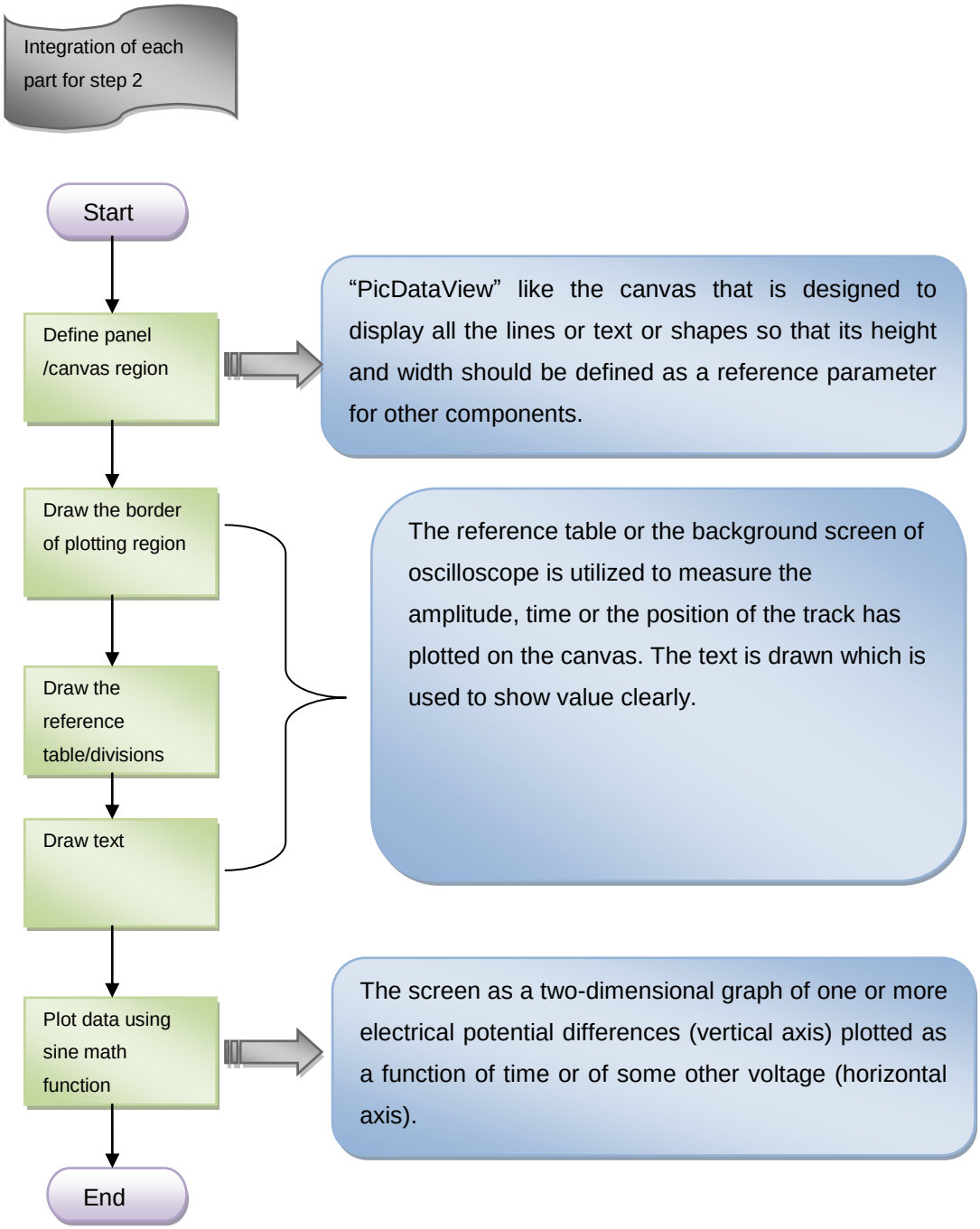


Figure 20 Integration of each part for step 2

Every related part for plotting data and drawing the reference table can be encapsulated into an independent subroutine named "DrawData" for example that will be make the program work efficiently and conveniently to call in the oscilloscope simulation section. And because of the programming for Windows is commonly known as event-driven programming, the subroutine "DrawData" must be called in the 'paint' event which is provided by the control itself and raised when the control is redrawn. Also, the data to be plotted should be happened in the run mode not the design mode.

The virtual serial port that is provided by the Visual Basic 2005 is used to perform the serial communication. It is also can be said it becomes a link between the programming language and the external device-USB module. So the testing is a necessary procedure during the project implementation. The flow chart on testing serial port is shown below:

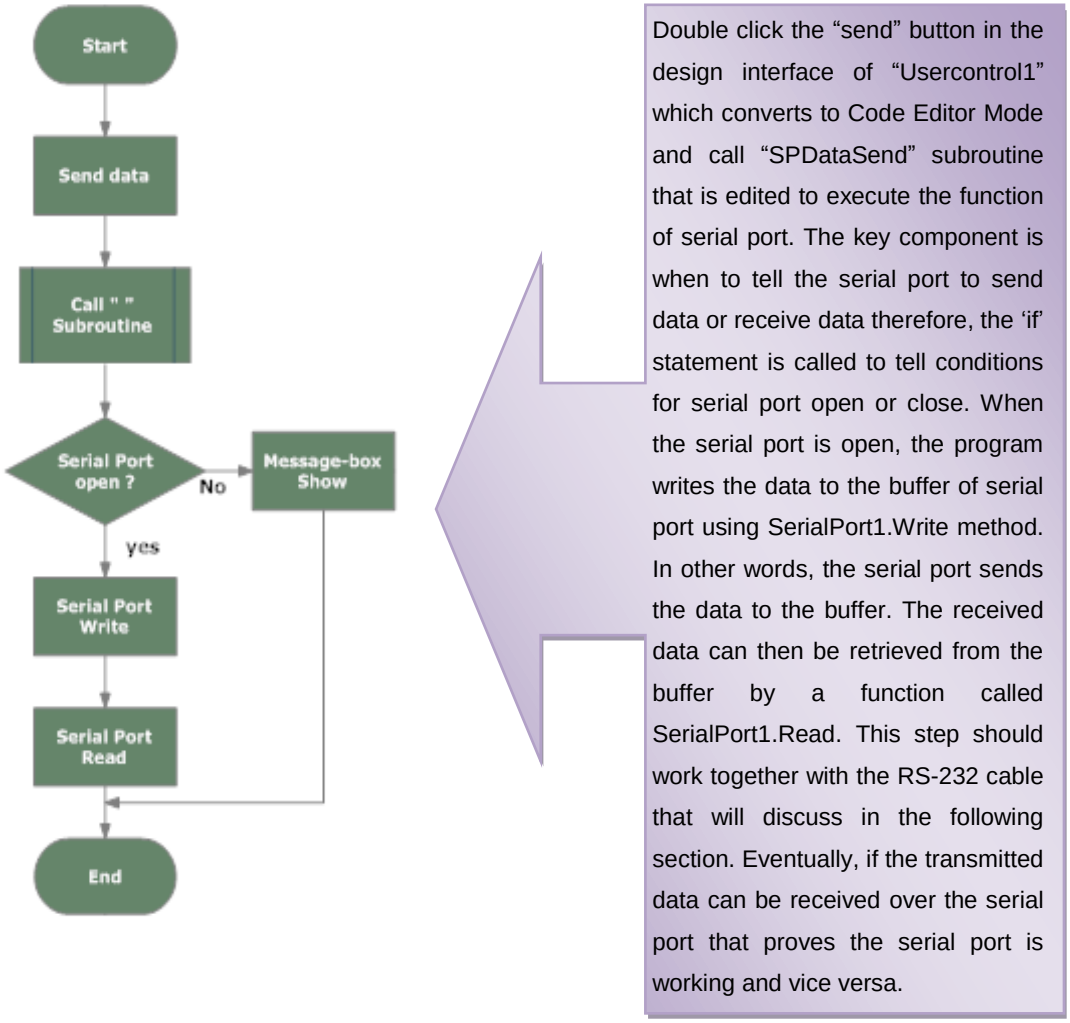


Figure 21Test serial port

Until now, the first objective on the graphical representation of data specific on plotting data using Active X control have completed . Many controls of the oscilloscope allow user to change the vertical or horizontal scales of the *V/t* graph, so that it can display a clear picture of the signal user want to investigate. The following procedure is the oscilloscope simulation. The general components can be designed as following illumined:

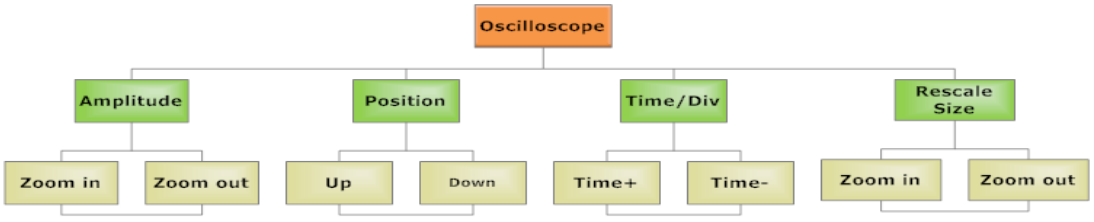


Figure 22 Oscilloscope simulation structure

According to Figure 22, actually, rescaling the control size in the run interface does not belong to the oscilloscope simulation and it is used when the user wants to observe and analyze more than one control in the interface as Figure 10 shown. Hence, designer should guarantee all the functions of the controls still working as expected. As for the amplitude, position and time, in the practical operation they are common controls of an oscilloscope therefore the aim of this part is to simulate their function. The flow chart listed below for every part will go into particulars:

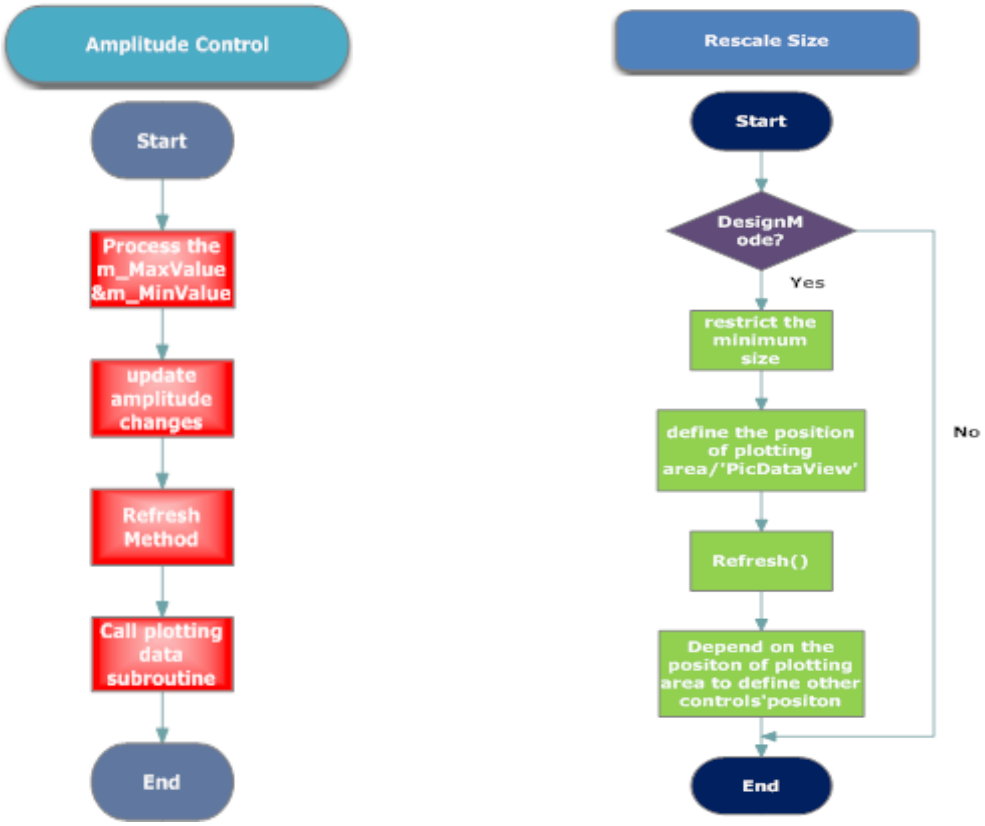


Figure 23 Sub-flowcharts for adjusting amplitude and rescaling size

The explanation on "amplitude" control:

- **Process the m_MaxValue & m_MinValue**: As mentioned in plotting data part, the "m_MaxValue" & "m_MinValue" can be defined to describe the amount of data intended to show which determine the scaling of y axis- "dy". Furthermore, the "dy" is used to define the y-axis of current point y1 & the next point y2 in the sine wave. On account of this, if the amplitude of the curve intends to be altered, the corresponding parameter "m_MaxValue" & "m_MinValue" should be updated as well. For instance, assuming multiply them by 1 as a reference level thus, the sine wave should be multiplied by 1.1 to zoom in and multiplied by 0.9 to zoom out. However, when it is zoomed in after several times, it will be drawn outside the reference table so that the source code should be developed to restrict the trace as Figure 18 shown above.

- **Refresh method**: the 'refresh' is utilized to avoid the variable overlapping of the amplitude.
- **Call plotting data subroutine**: this subroutine points to the "DrawData" mentioned above that includes about drawing reference table and plotting data. When click the "zoom in" or "zoom out" control the track will disappear if the "DrawData" subroutine is not called.

The description on rescaling size:

Only at the design mode, the control in the run interface named "usercontrol11" (Figure 10) can be rescaled the size and ideally, the control size can be changed to any standard. But the size has to be specified a minimum value logically for all the controls can be visible in the screen. Since there are many controls need to be defined the position according to the size of "usercontrol11" that can be found by using the 'resize' event which indicates using the width or height property can set the window width and height independently. On this condition, a reference position such as the position of "PicDataView" (Figure 8) should be defined by the width and height of the "usercontrol11" first. And then the position of another controls added in the "usercontrol11" can be defined based on the "PicDataView".

When it comes to altering the position of the sine wave, the flow charts in next page indicate that it goes down and goes up separately. Adjusting Y-POS allows the zero level on the Y-axis to be changed, moving the whole trace up or down on the screen to give an effective display of signals like pulse waveforms while do not alternate between positive and negative values of x axis.

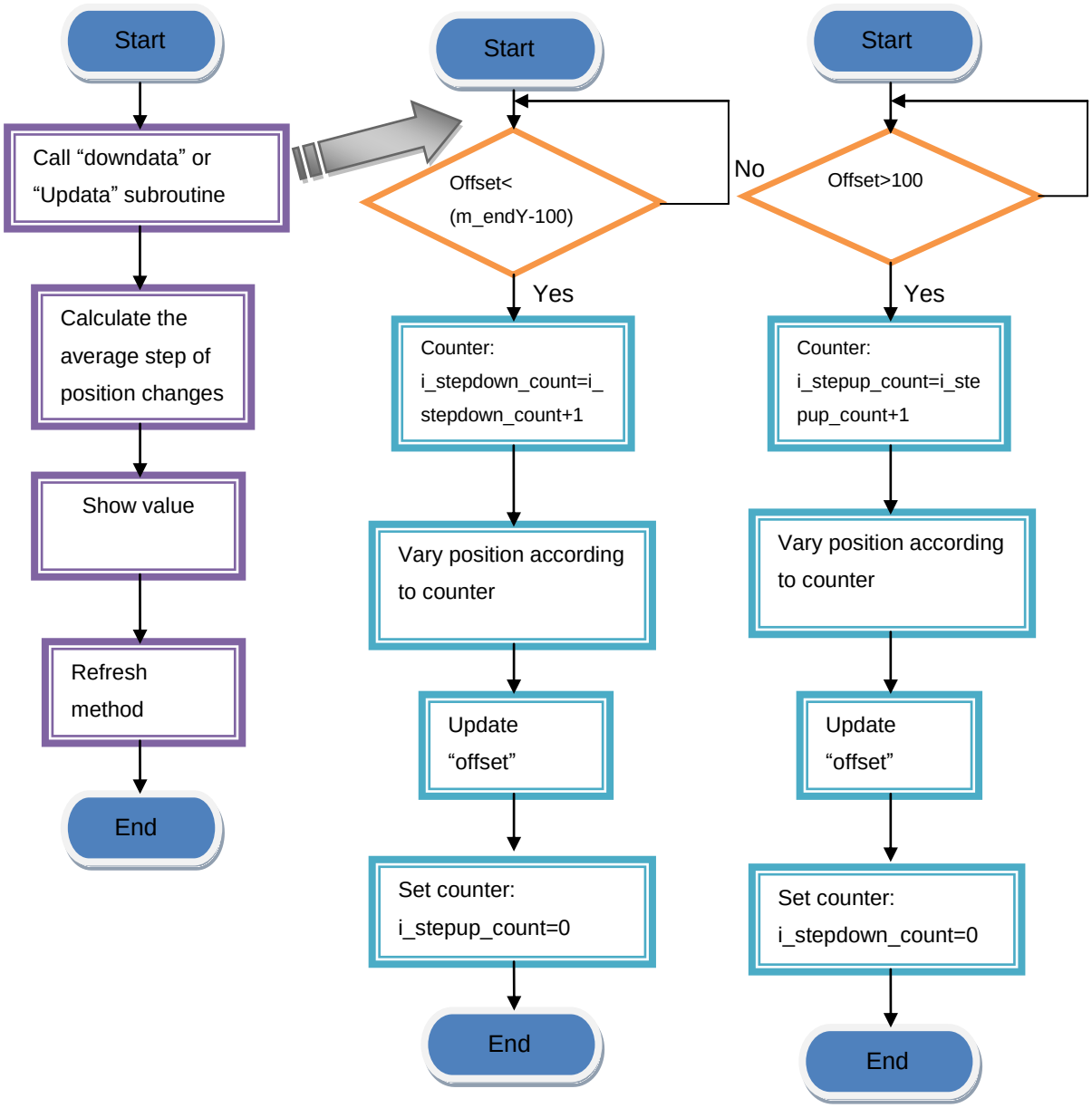


Figure 24 Sub-flowcharts for position control “down” (middle) &”up” (right)

The discussion on the “downdata” subroutine in Figure 24 (middle) (nearly the same as “updata” subroutine):

- **Offset< (m_endY-100)**: m_endY equals to the height of the “PicDataView”. Using the ‘if’ statement is to avoid the sine wave disappear from the region for plotting.
- **Counter: i_stepdown_count =i_stepdown_count+1**: i_stepdown_count is defined as a counter to adjust the position and it will be added by 1 as the “down” button is clicked every time automatically so that it is also a necessary variable for calculating the magnitude of position changes.

- **Vary the position according to counter**: actually, the value of position changes are ready for updating the "offset" that is based on the "i_stepdown_count".
- **Update the "offset"**: if "offset" changes, initially it is in the middle of the reference table, all of the related points will remove together that result in the track will move as well. Additionally, the "offset" must be determined by both of up and down position changes to avoid jumping steps that means when the curve needs to go up or go down from the current position.
- **Set the counter: i_stepup_count =0**: after adjusting the curve to go down, the other counter "i_stepup_count" must be set to zero that is because this statement is used to avoid jumping steps due to whenever finishing the "up" function and converting to the "down" button the other counter should be added from start. Simply speaking, the two counters for controlling the curve to go up and go down must be independent from each other. (in the following section of function judgment will discuss this point graphically)

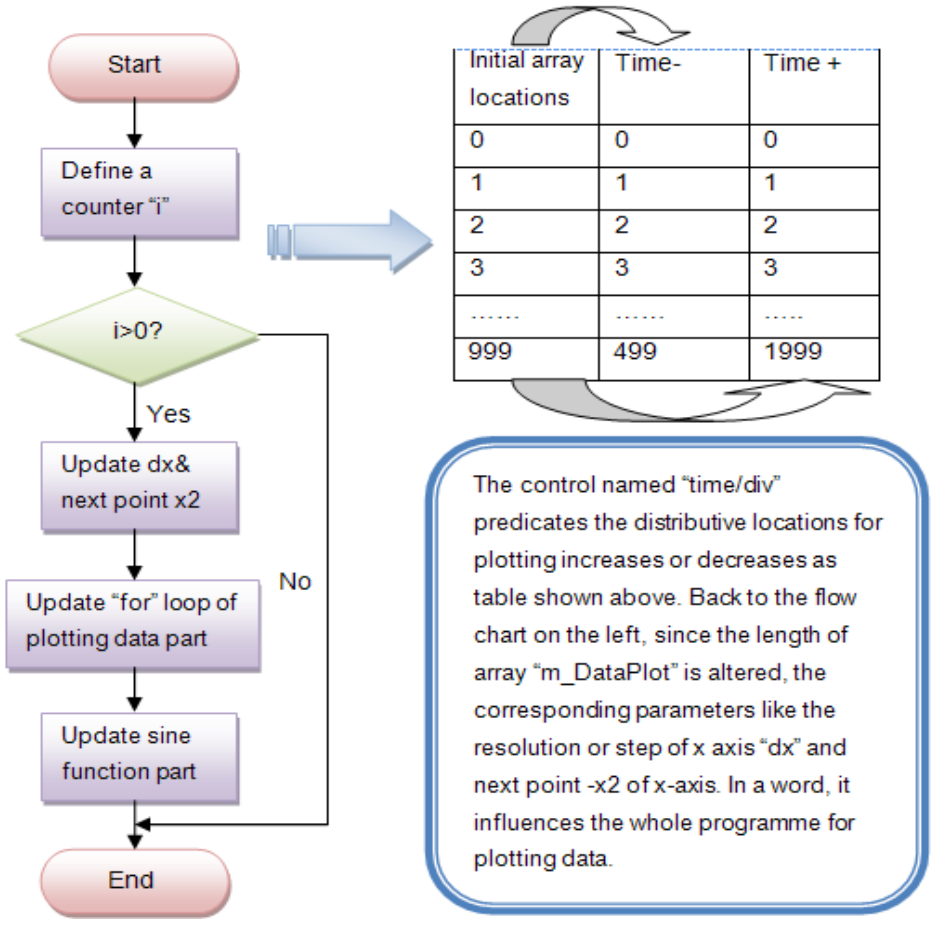


Figure 25 Sub-flowcharts for "time/div" control

After finishing the oscilloscope simulation, the second objective on developing the required graphical interface like oscilloscope for presenting the graphical data to the user has almost come true. So, the next part is about the third objective to develop the programming for communication between the USB and PC. The flow chart can be designed as following:

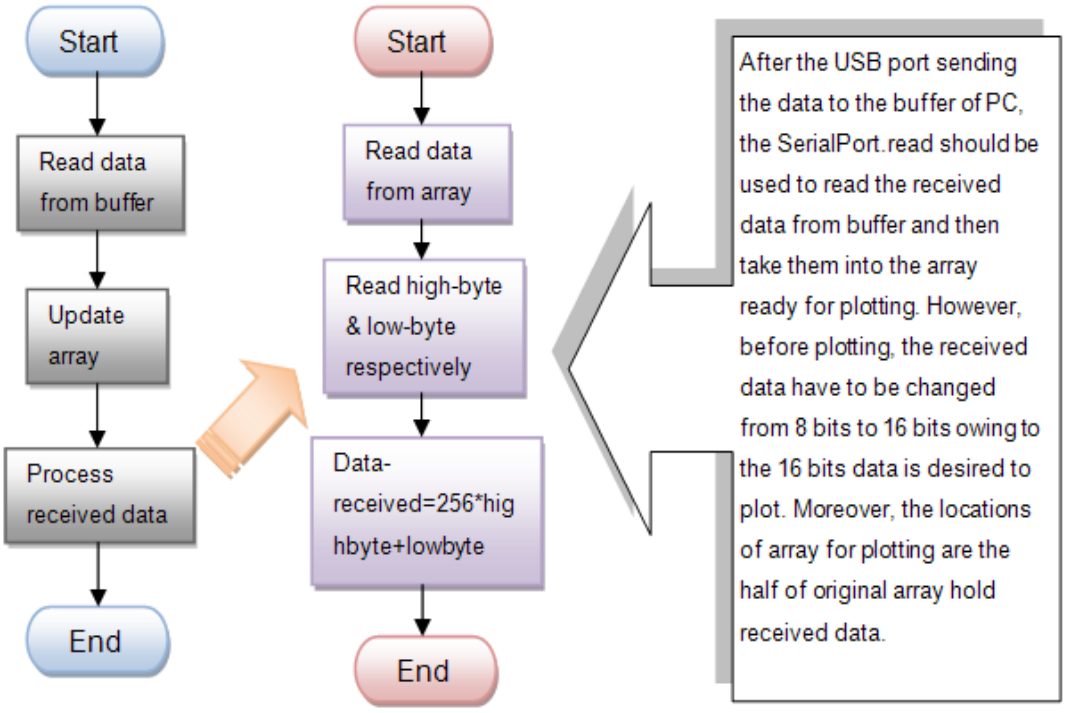


Figure 26 USB communication with PC

2.2.2 Integration of the logical sub-flowcharts

Referring to Figure 27 below, additional description should be listed as the following:

- **COM Port configuration:** as mentioned in the project design section (Figure 9), the programming for realization the serial port setting including the initialization and configuration of Ports' name, BaudRate, Parity, DataBits and StopBits by using an independent interface should be performed. Then it connects with the main interface over "USB" button (Figure 8).
- **Add new property**: in the practical condition, when the custom intend to change some property of user controls but considering that they are not allowed to control the design interface (Figure 8) and only have access to the run interface (Figure 10), adding new property to the control is a desired function. And then in the Properties window, it will appear under the existent control category. In that case, the custom can change some property optionally for instance the background of the screen or the line color of the sine wave depends on themselves.
- **Install USB:** as a matter of fact, the installation of USB is about the hardware development including the powered configuration and USB driver installation.
- **Develop programme for communication:** when this step have been ready for communicating, some corresponding parts will be updated together.
- **Offset:** as for transforming position, time or amplitude, this key variable have to be changed from local to globe type.

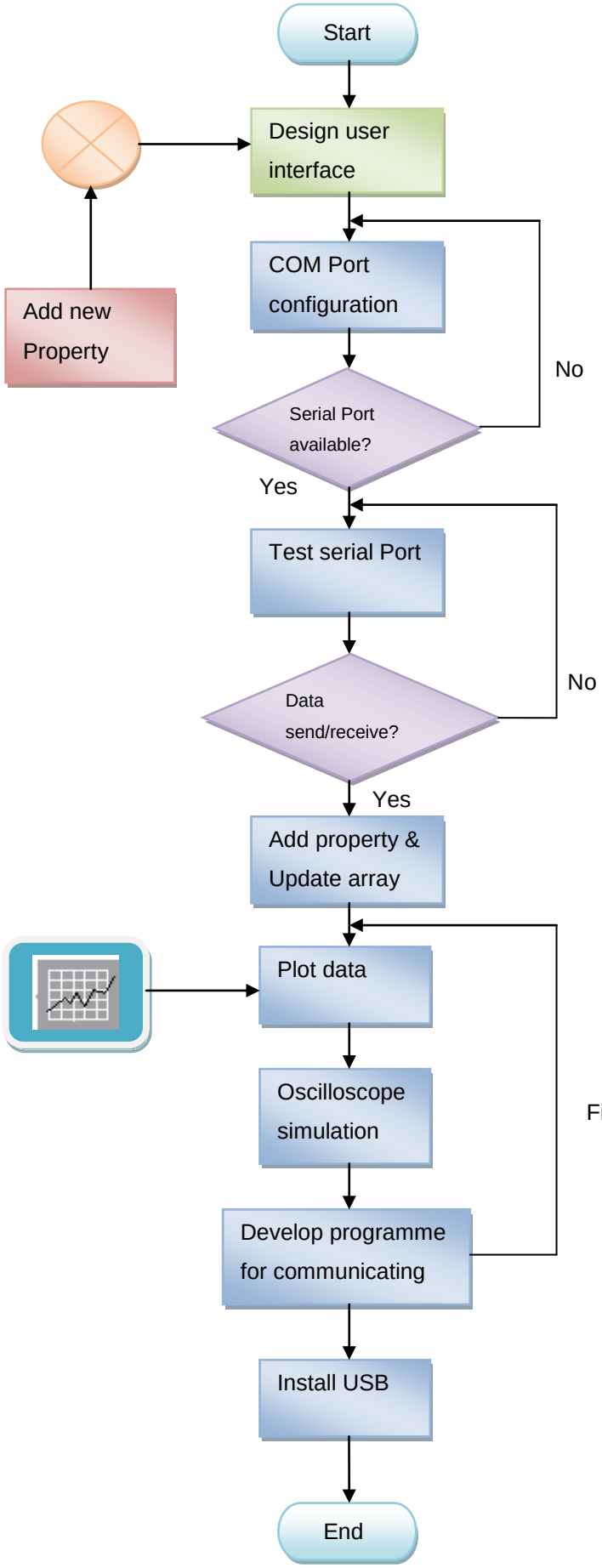


Figure 27 System flow chart

2.2.3 The function judgment

2.2.3 a) plot data

Generally speaking, to plot data graphically should process the following procedures:

- Storing data in the array
- Reading data from array
- Plotting data using math function

Commonly using 2- dimension-x, y to express the pixel or coordinates point that make up of the track drawn in the screen. Sine Y-dimension stands for the data from array, all of them should be drawn out one by one for plotting shown as table below. It is the counter that defined to control reading data. Also, the plotting is a durative process and all points in the track can be only described as the current point and the following point. Hence, the points should go ahead that can be driven by x1equals to x2. Finally, the math function is called to manage these relative points so that the plotting is working successfully.

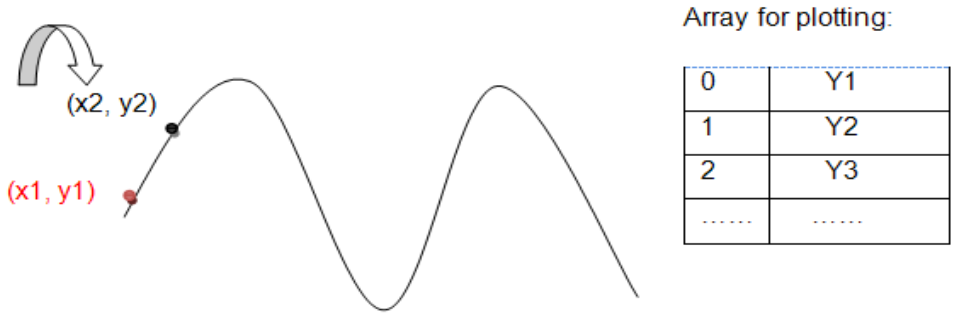


Figure 28 Plot data

2.2.3 b) oscilloscope simulation

When it comes to the “position” control, there are two important parameters to drive it to work as expected.

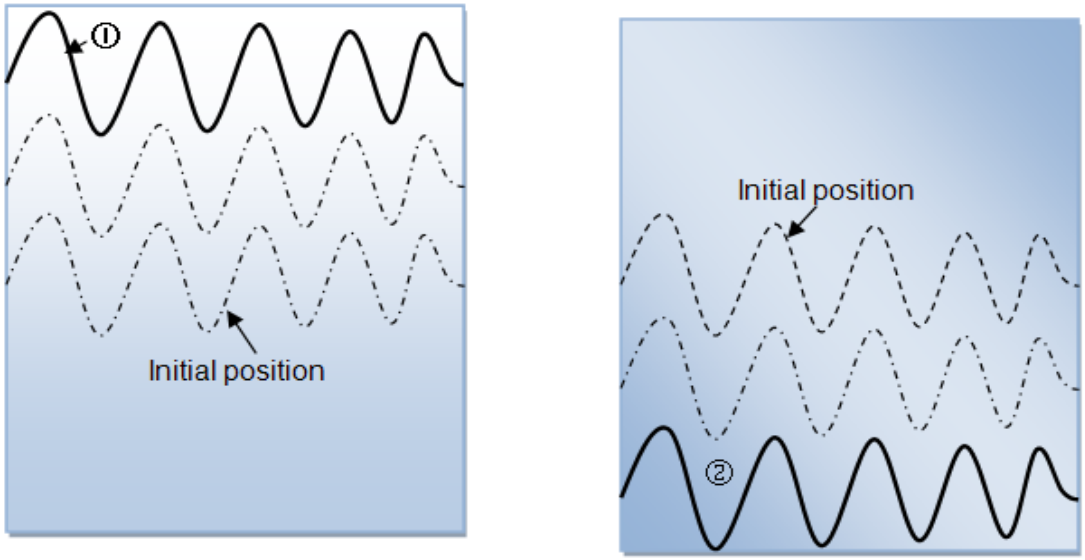


Figure 29 Position changes simulation

He, Miao / PC Oscilloscope USB based

As figure above shown, when the curve goes up twice at point ① and then goes down must be from this current position not the initial position to avoid jumping steps. Therefore, in the programming design, there was a parameter defined to record this position added to the calculation of "offset". If the curve goes down from point ① to point ② and then need to go up again, the other parameter also can be said the counter for controlling the trace to go up should be forced to zero because the counter always record the last position, in that case, when click the "up" button the curve will go up to the top of screen straight. Following this point, the system can execute as expected.

As for "time/div" control, the project does not work perfectly because the sine wave can be only adjusted the amount of periods has drawn in the window not the locations of array for plotting. Maybe the reason is that the resolution of x axis has not been considered or some variables need to be declared as globe not local.

Another disadvantage on this system is that the communication backchannel between the USB and PC still exist some problem due to the serial port cannot read all of data from the buffer array if the statement "serialport.read" is only used that result in it just read the last received data in array. Hence, only single data can be read from buffer not a set of data received from USB.

2.2.4 Hardware development

2.2.4 a) using RS-232 cable to test serial port

Refer to the "pinout" of RS-232, the pin#2 describes the received data and pin#3 describes the transmitted data. When using single PC to communication, the Female (DCE) end of the cable should be hanged and then the pin#2 and pin#3 should be connected together that forms a loop to transmit and receive data. When the serial port in PC was open and then clicked the "send" button, the data written to the buffer would be send out and then went back to the PC via RS-232.

Figure 30 shows the main RS-232 connection for 9-pin connections without hardware handshaking. The loopback connections are used to test the RS-232 hardware and software. The program on testing part used a loopback on the TD/RD lines so that a character sent by the computer will automatically be received into the receiver buffer. This set-up is useful in testing transmit and receive routines. The character to be sent is entered via the keyboard. [2]

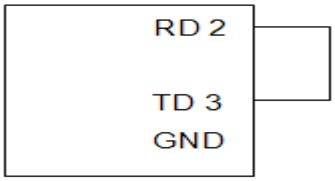


Figure 30 9-pin D-type connector (loopback)

2.2.4 b) the installation of DLP-USB245M User manual

During this step, there are two sub-steps should be undertaken.

- ❑ USB adapter Powered configuration
- ❑ The installation of USB driver

The bread-board, USB cable and DLP-USB245M User manual could be used together to carry out the installation. As stated in Appendix C, the bread-board connects components together to build circuits and the leads of most components can be pushed straight into the holes in the board. The USB cable could be used as a connector between the USB port and PCs. The type “B” usually connected to the DLP-USB245M and the other end “A” connected to a conventional host hub (Figure 11). As shown the pin configuration (Figure A-1), the pin#1 & pin#4 of the cable describes the power supply –specification 5V and pin#2 & pin#3 are for transmitting and receiving data. After plugging the USB into bread-board, the circuit connections to supply power according the Figure below shown had to be completed.

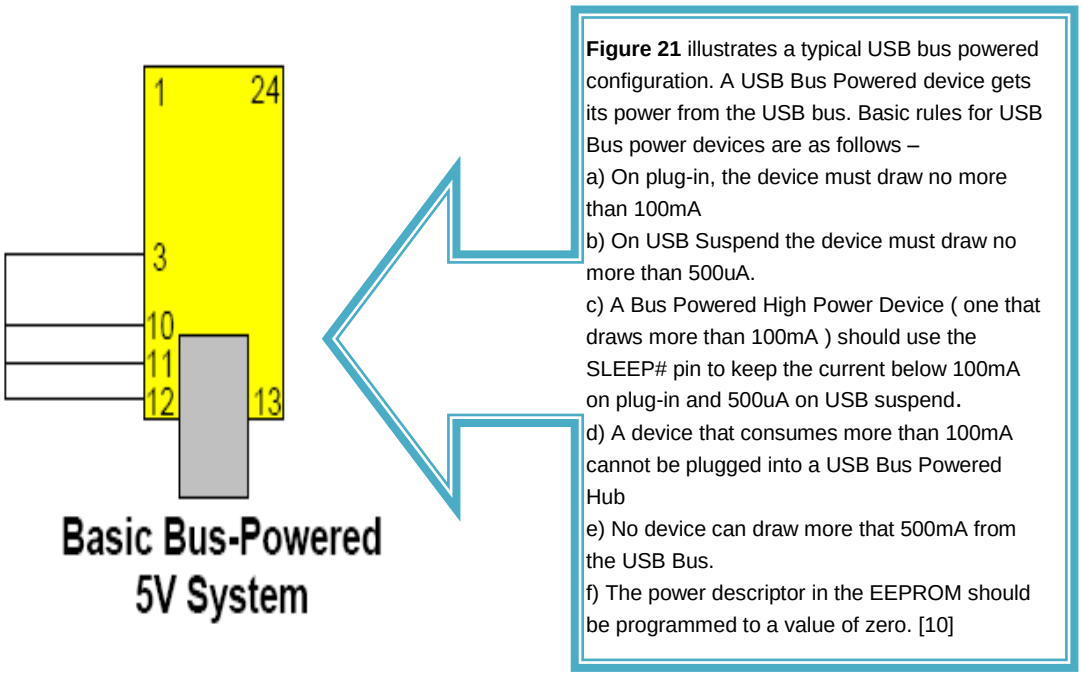


Figure 31 USB Bus Powered configuration [10]

Based on the DLP-USB 245M pinout description (see the Appendix B), pin#3 should connect with pin#10, pin#11 and pin#12 respectively which supply 5V power to USB. The pin#13 should connect with pin#14 that provides handshaking signal RXF# and TXE# to transmit and receive data.

The USB driver is necessary component for DLP-USB 245M working with PCs. The following step on installing the USB driver [10]:

1. Download the DLL version of the device drivers from either dlpdesign.com or ftdichip.com. Unzip the drivers onto a blank floppy disk or into a folder on the hard drive.

2. Download the serializer program from either dlpdesign.com or ftdichip.com. Unzip the package and place it in a folder on the hard drive.

3. Connect the DLP-USB245M board to the PC via a standard, 6-foot USB cable. This action initiates the loading of the USB drivers. When prompted, select the folder where the DLL version of the device drivers were stored in step one. Windows will then complete the installation of the device drivers for the DLP-USB245M board. The next time the DLP-USB245M module is attached, the host PC will immediately load the correct drivers without any prompting.

4. Run the serializer program and write the VID (0403), PID (6001), a description string of the users' choosing and manufacturers ID as instructed in the instruction manual that was downloaded with the serializer software. Terminate the serializer program and disconnect the DLP-USB245M board from the USB cable. Wait 10 seconds and reconnect the DLP-USB245M board. Reboot the PC if instructed to do so. [10]

After installing the driver, under the "Device Manager" of PCs the "USB serial port (COM port) and USB serial converter would appear automatically. That means the USB driver can retrieve COM ports from the system and automate the selection of COM port to the height available. The USB serial port also can be said as Virtual COM ports that is a link between the programming language or software development and USB module.

Summary

This chapter introduced the project implementation consists of programme development and USB port installation. The previous one utilized several logic flow chats to describe how to plot data and how to realize the oscilloscope simulation. As for hardware development, mostly referred to the data sheet of the DLP-USB 245M user manual to perform how to plug the USB into PCs.

Indubitably, the following chapter should lay out the testing results together with required explanation.

Chapter 3: Testing and debugging

Chapter overview

After discussing the project design and implementation together with the analysis of function judgement, this chapter will present the testing results including the tack and oscilloscope functions shown and different waves display using some common math models. Also, error analysis depends on the results shown will be involved.

3.1 Test result

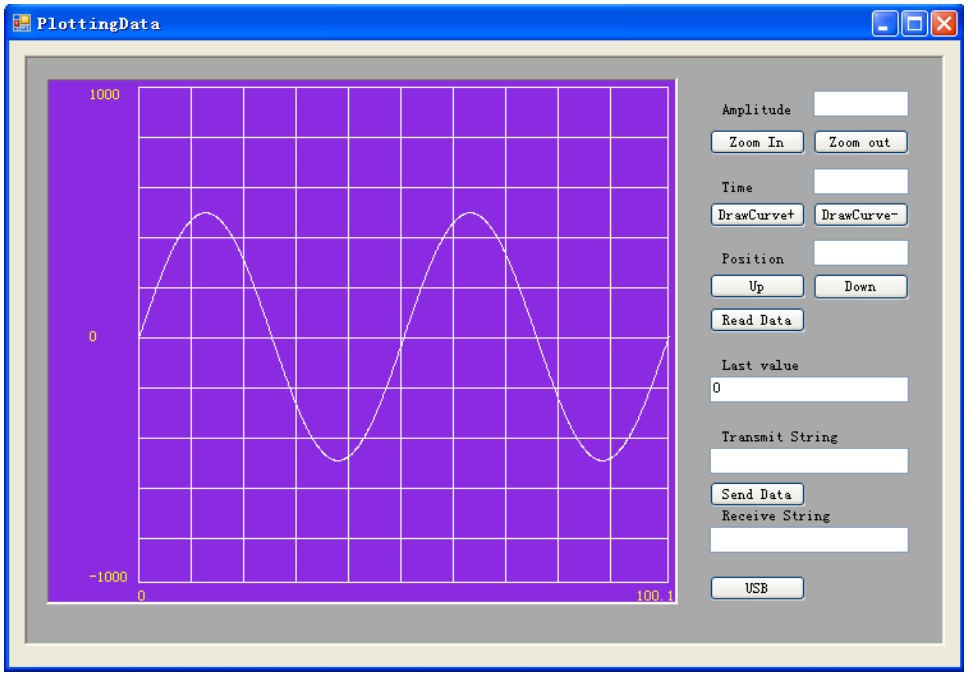


Figure 32 Representation of data graphically

Using sine function with proper parameters defined such as amplitude and period, the correct sine wave was drawn on the plotting region-“PicDataView”. The texts in the screen were designed to measure amplitude, position and time of the curve. The “offset” had emphasized before was working as expected. The graph was restricted to draw from the vertical midpoint that made it looked like more symmetrical and convenient to scale. The “last value” displayed the last data in array abstractly. In addition, the parameter in the sine function must be defined larger than the locations of array. If it is only the half of the locations, the half of the sine wave will appear that results in waste of room. Adding two controls in user interface is a convenient way to analyze the two graphs. (See Appendix A)

The following two pictures show the amplitude changes:

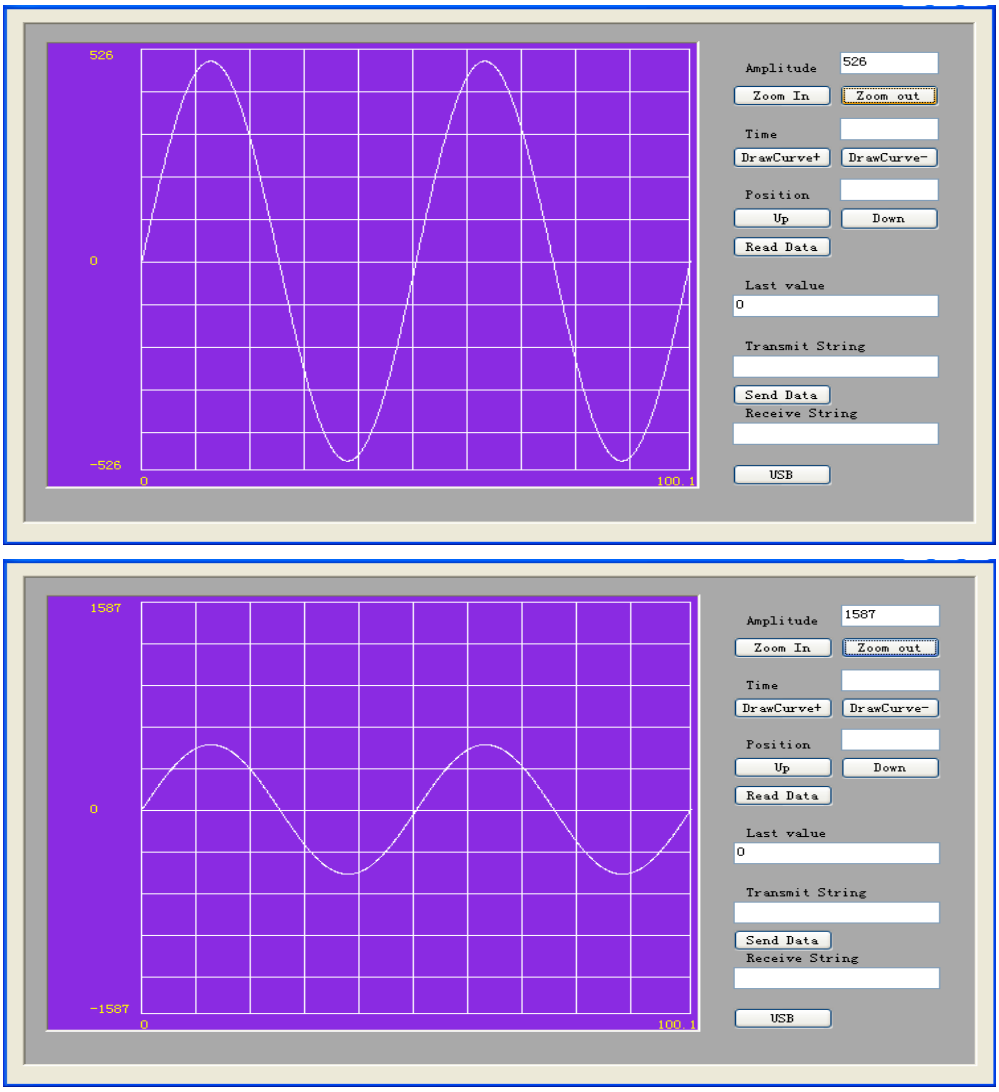


Figure 33 Oscilloscope simulation- amplitude changes

When clicked on the “zoom in” button, the amplitude increased as the magnitude decreased that was because the specification of this coordinates system was (0, 0) at the top-left of the screen. Likewise, the wave zoomed out as the magnitude increased in Figure 33.

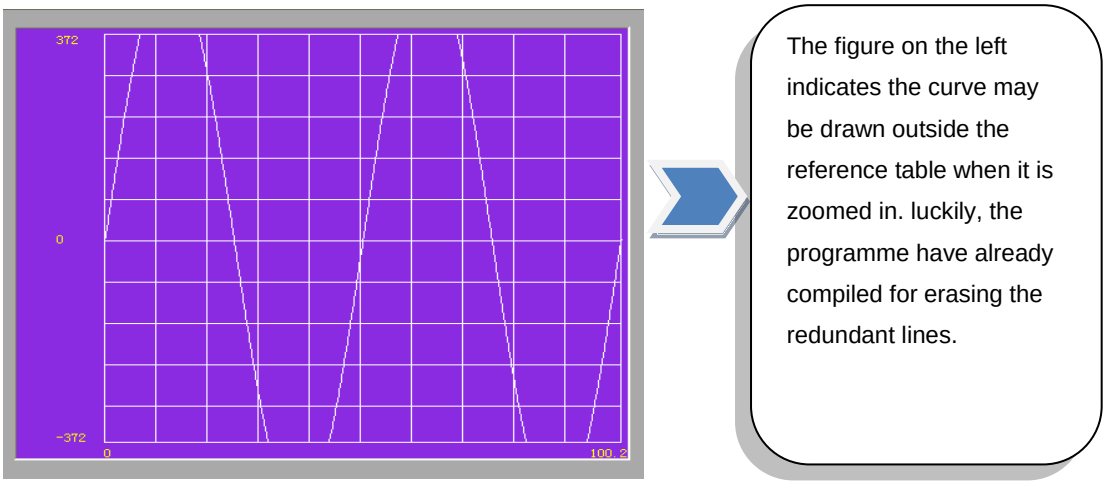


Figure 34 Special situation of amplitude changes

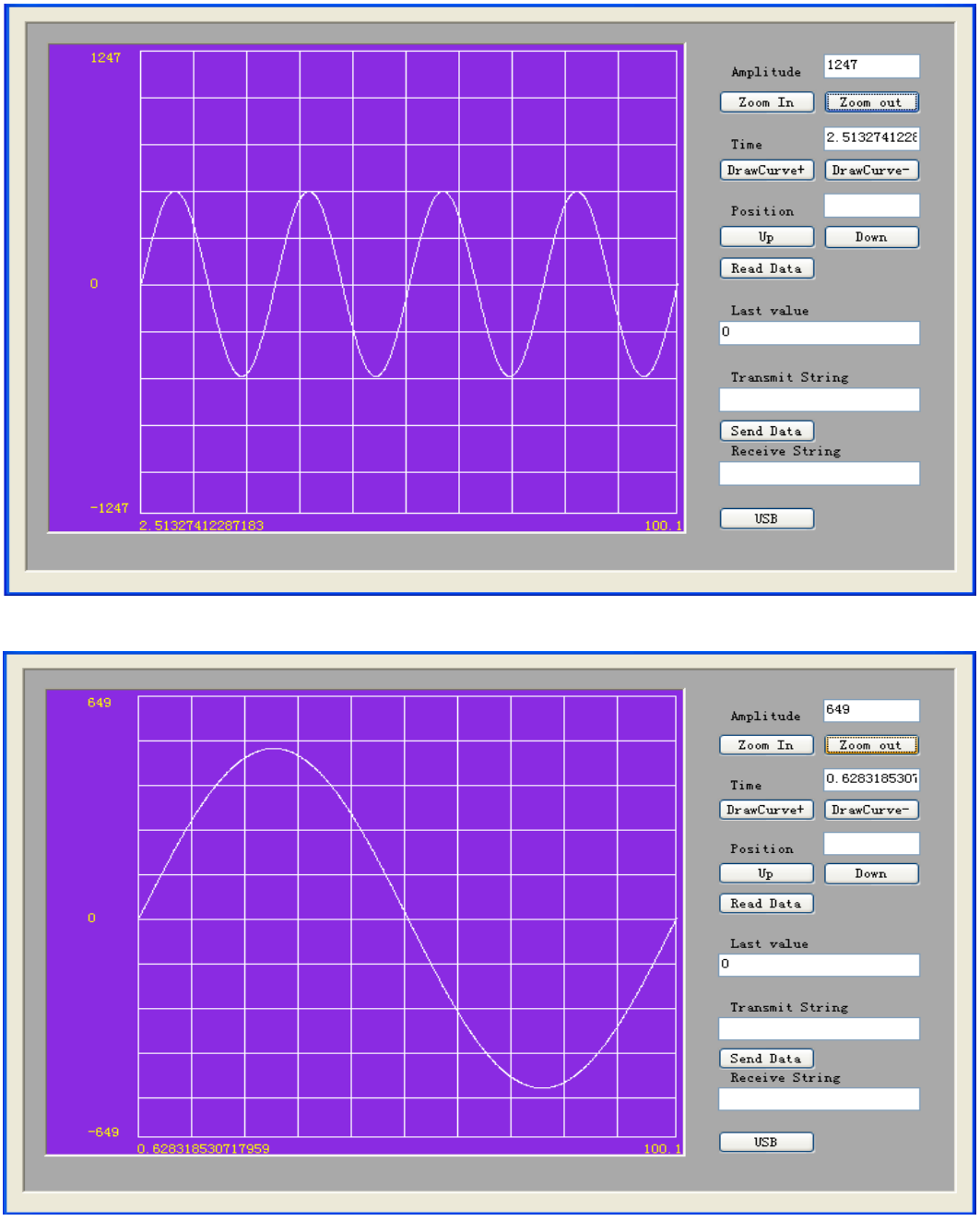
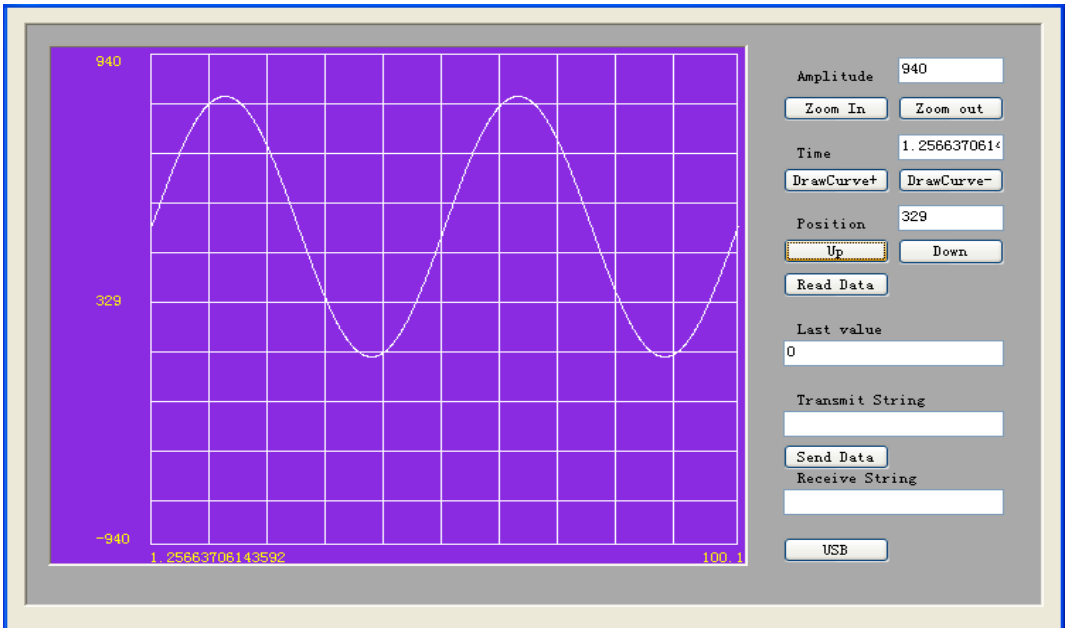


Figure 35 Oscilloscope simulation-“time/div”

On this condition, the “time” control was designed to change the periods of sine wave drawn. And the texts on the left of x axis determine the horizontal scale of the graph which appears on the oscilloscope screen. For example, With 10 squares across the screen and the spot moving at 0.628 s/DIV that is 0.62831 * 10 = 6.2831≈ 2π. The period of the curve can be calculated. At the same time, the amplitude can be altered as well depend on users themselves. In fact, for this project the “time” control means the locations of array changes for plotting in that case, the realization of function here is not exactly that will particularize in the error analysis part.

The Y-POS control allows user to move the spot up and down the screen. For the present, adjust the trace so that it runs horizontally across the centre of the screen.



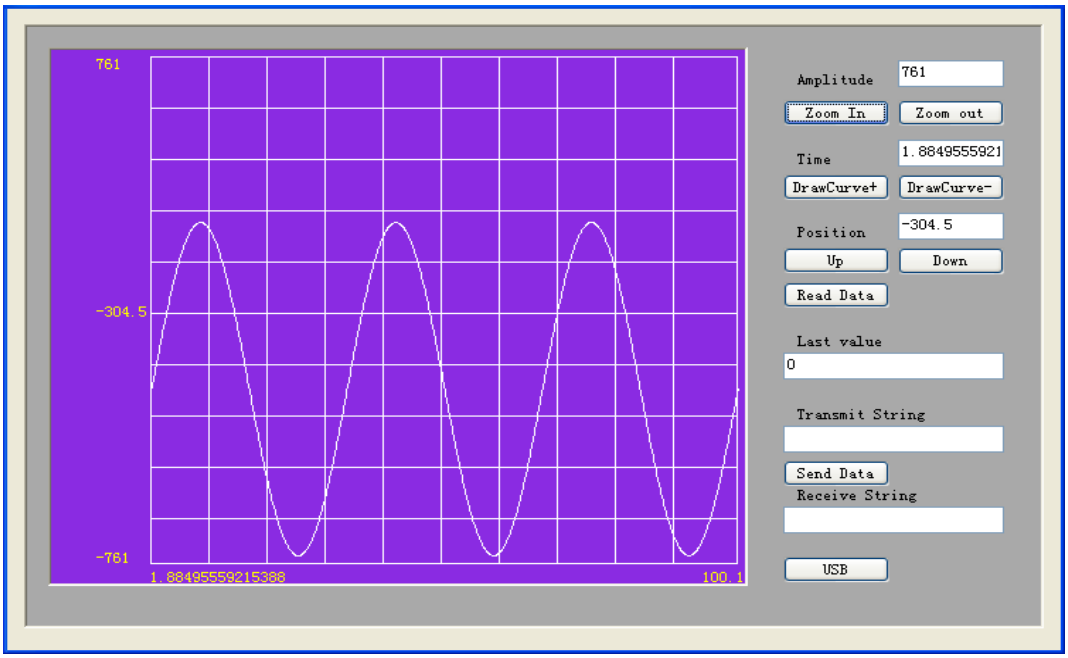


Figure 36 Oscilloscope simulation-“position” control

The variable “offset” is the most important factor for controlling the position changes and it must be changed to define as the globe variable. If “offset” is still the local variable, when using another controls like amplitude with the “position” simultaneously, the sine wave will go back to the original position not currently. Also, the “offset” here must be related to the “offset” of the data are plotted part. Likewise, the amplitude or the periods can be transformed as well. Like adjusting the VOLTS/DIV and TIME/DIV until a clear picture of signal can be obtained. However, the corresponding numerical value is not exactly, in particular, when the curve goes up or goes down continuously.

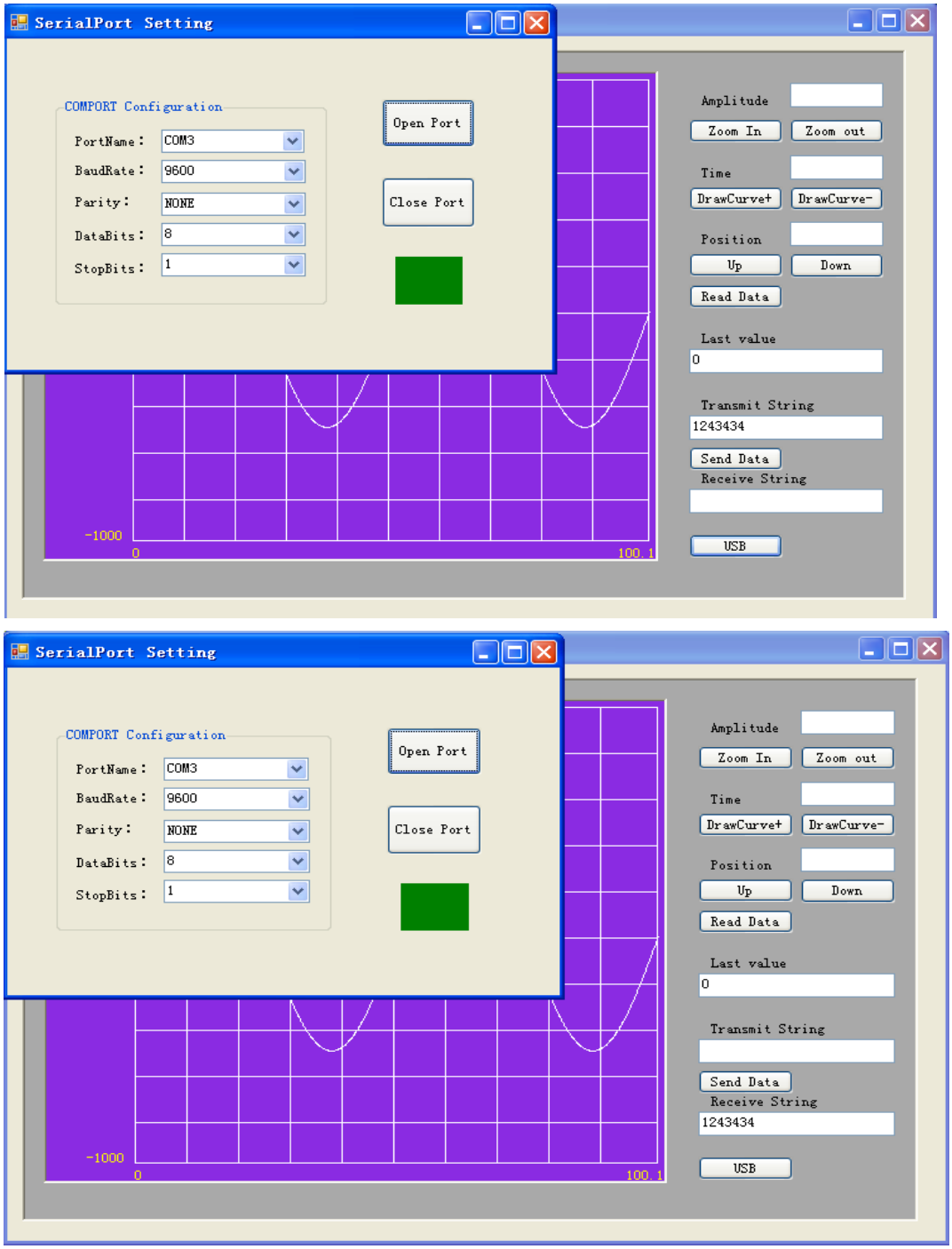


Figure 37 Serial port test

According to the project implementation, there are there steps for testing:

- ❑ Connect RS-232 with PCs
- ❑ Click on “USB” button
- ❑ Select required COM Port and open it (the alert light show green)
- ❑ Write the random value in the “transmit string” text box
- ❑ Click on the “send” button

Afterwards, from Figure 37 above, the written number disappears from the “Transmit String” box and then the same value appear in the “Receive String” that proves the test is successful.

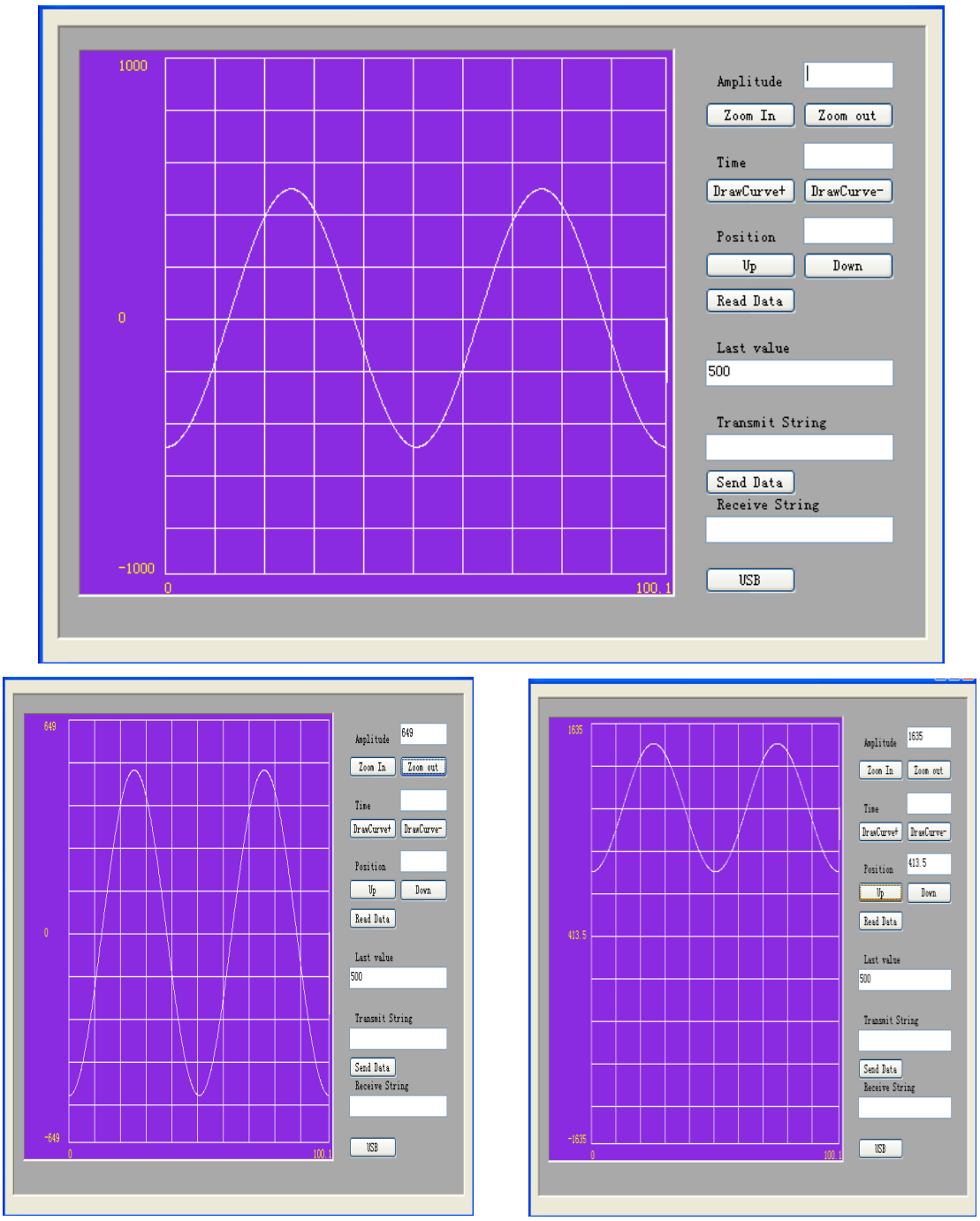


Figure 38 Different wave-Cos function

By changing the math function, the different trace can be achieved. In the same way, the amplitude or position of cos wave also can be changed shown as Figure 38 above. Actually, from the “last value” shown that records the first point in the track therefore, according to the math function, the sine wave should be zero while the cos wave should be 500. But when adding the “timer” control in the user interface, with the help of programming language the “last value” is mutative and durative number which also can be used to simulate the received data from external devices such as USB module.

Other waves also can be achieved by using different math function for instance: Truncate Sqrt, Tan or Round and etc. (see Appendix A)

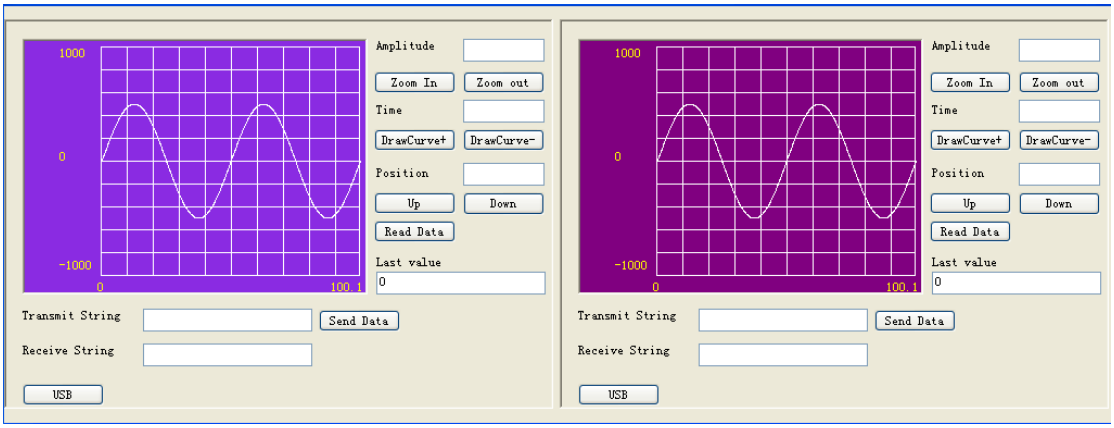


Figure 39 ActiveX control reusable

Adjusting the size of each control to ensure all controls could be visible and usable in the run interface. Also, these two traces could be altered the amplitude or position within Appendix A.

3.2 Error analysis

3.2.1 Plot data

Theoretically, the “offset” should minus the data derived from the array when calculate the y-dimension of the current and next point (y=offset-m_DataPlot (i)*dy). However, in that case, the curve shifted abnormally as shown below:

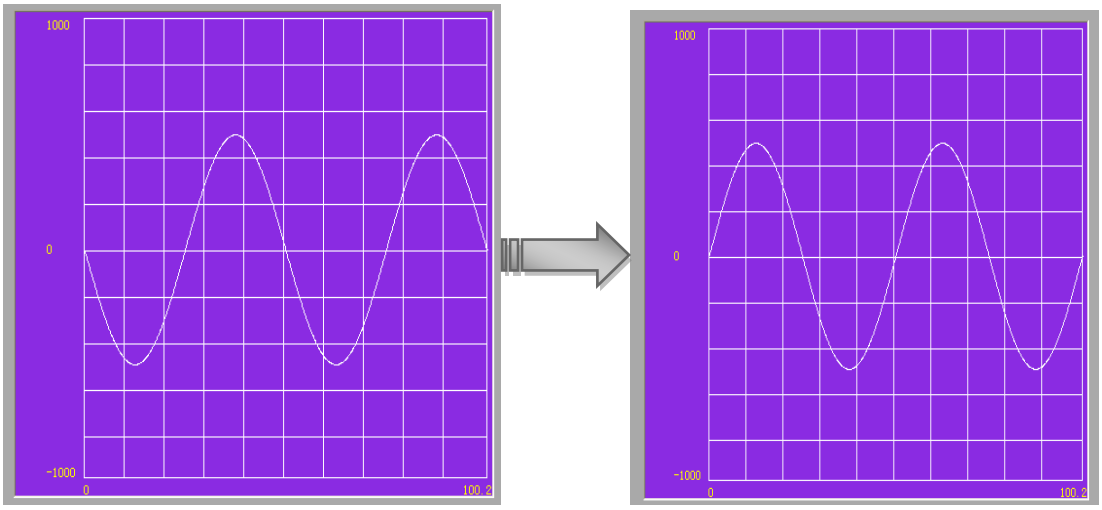
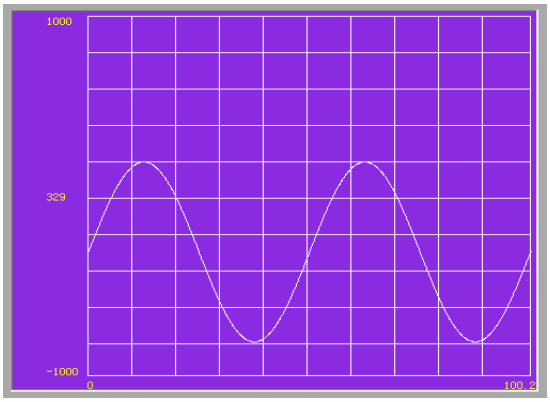


Figure 40 Turn analysis

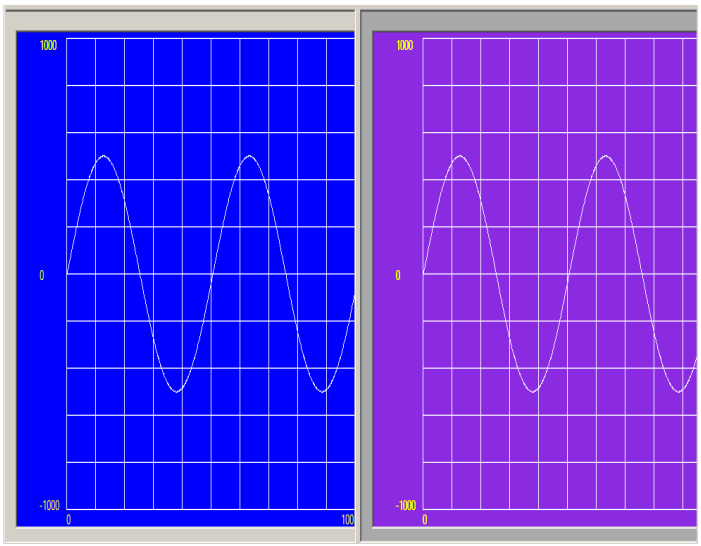
The reason of the curve on the left happened is that in the “update array “part, the array is updated from the bottom of array (m_DataPlot.Length - 1 To 1 Step -1) not from the top results in the order of plotting data should be from maximum value to minimum (t = 1000 To 0 Step -1) when using the sine function and vice versa. When both of them were provided with the correct corresponding relationship, the expected result would lay out (right). Alternatively, changing the equation -y=offset-m_DataPlot (i)*dy to y=offset+m_DataPlot(i)*dy is also a solution.

3.2.2 Oscilloscope simulation



When the “up” and “down” button were clicked continuously, the value for explaining the position changes was not correct any more (329). That is because the “offset” displacement does not respond to the show value.

Figure 41 Show value analysis



When added two controls in the run interface, from figure left, there was just waveform no other controls anymore although the size rescaling had adjusted. Back to Figure 39 that was an updated design interface over readjusting the controls’ size and position, this was not an expected step. The improvement is that the programming on recalling size has to be correct. Maybe, more than one reference positions should be utilized to define the controls’ positions and size.

Figure 42 Reusable user controls

3.2.3 Serial port test

When using the RS-232 cable to test port, oftentimes the “send” button had to be clicked twice that only enable the transmitted data can be received. Maybe the reason is that there is some delay occurred when the data is transmitting over the cable or the Baudrate is set to 9600 therefore assuming “12345678” is sent, the speed of transmitting should be:
$8*(1/9600) = 8.33e^{-4}$ which is too fast to catch up.

Summary

This chapter described the results of the programme debugging along with comments. Also, the possible reasons and recommendations for arisen errors were discussed. The last chapter below will provide a concise summary of the major finding and outcomes of the report.

Chapter 4: Conclusions and future development

Chapter overview

In chapter 4, the conclusions of project work consist of the difficulties encountered, the updated processes, the summary of the investigation and the future development, improvement and future direction of the current project will be discussed.

4.1 Project work summary

4.1.1 Practical outcomes

The points below are similarly with the objectives mentioned in the introduction part before.

- A new programming language-Visual Basic 2005 has been learnt generally.
- The user interface has built by using different controls.
- How to use ActiveX control to develop the required graphical interface has been implemented.
- The related data has been plotted in a graphical format.
- The basic functions of oscilloscope simulation have been developed.
- The fundamentals of external interface devices such as RS-232 cable and DLP-USB245M User Manual have been understood also their applications have been involved during the processes of this project.
- The realization of communication between USB and PCs are developing and the ideas and partial source code have already completed.

The listed information above is the major findings of the project. Obviously, there are some improvements and further development which can be carried into execution in the further.

4.1.2 Cost and market needs

Based on costing in the Introduction and brief description about PC-oscilloscope in Subject Overview, the components or small items of equipment and necessary software package for this project were nearly available in the University. So the project budget within the maximum available budget-£50.

The PCO is the modern alternative to traditional bench-top oscilloscopes that will be more popular as the development of software. Moreover, the PC can supply higher resolution and different colour for individual trace that bring a convenient and comprehensible way to observe or analyze required trace. Additionally, since prices can range from as little as $100 to as much as $2000 depending on their capabilities, it is commonly acceptant tool.

4.1.3 Report conclusion

This report introduced the statement of the background of the subject, the reasons for undertaking the work, the aim and objectives and the methods employed to achieve these objectives at the beginning. It also contained the descriptions and explanations of project implementation throughout the period of project work with the help of flow charts. What is more, the test results were shown using diagrams together with essential discussion. In the end, the future direction of the current project was discussed.

4.2 Processes lay out

		TASK NAME	SD	ED	Duration
A		**Project Specification**	10.10.07	17.10.07	1w
B		**Feasibility study**			
		• Literature research	10.10.07	31.10.07	3w
		• Understand Background information	10.10.07	31.10.07	3w
		• Write feasibility report	24.10.07	31.10.07	1.5w
		• Read past report	17.10.07	03.11.07	2.5w
C		**Analysis and Understanding**			
		• Design Block diagram of system	03.11.07	14.11.07	1.5w
D		**Study and Review**			
		• Visual basic 2005	14.11.07	31.01.08	7w
		• operation and architecture of USB	07.01.08	25.01.08	2w
E		**Project seminars**	10.12.07	14.12.07	1W
F		**Visit by external examiners**	07.02.08	14.02.08	1w
G		**Design and Implementation**			
		• Design interfaces using controls	14.11.07	28.11.07	2w
		• Develop ActiveX control for plotting data graphically	21.11.07	14.03.08	12w
		• Develop communication program between USB and PC	21.02.08	07.03.08	2w
		• Hardware installation	28.02.08	14.03.08	2w
H		**Test and Debugging**			
		• Test project	21.02.08	14.03.08	3w
		• Evaluate test results and correct software developmen	28.02.08	14.03.08	2w
I		**Write formal report**	28.02.08	07.04.08	4w
J		**Project reviews and ready for presentation**	07.04.08	14.04.08	1w
K		**Poster Session**	14.04.08	30.04.08	2w

Figure 43 Processes display

Revised Gantt chart within Appendix D will show 'time organization' of this project. (Figure A-3)

4.3 Difficulties in the procedure

✧ Indubitably, the study and application of new language-VB 2005 had to spend much time and energy together with lots of challenges must to be overcome. So, this procedure had gone on almost three months. Additionally, after studying the programming language, the subjects were relative to the serial communication that had not been mentioned. Hence, how to compile the programming was still a new problem.

✧ The confusions on the aim and objectives of project and the unfeasible actives that resulted in waste time.

✧ As for developing program for plotting data, at the beginning the choice of method did not support by VB 2005 but VB 6.0. Afterwards, the scaling or average steps of X axis and Y axis were not took into account the programming so that the desired waveform could not achieve. Also, the control of some key variable like “offset” was a complicated operation. Sometimes, it must be defined as globe but maybe brought confusion to the program debugging furthermore, some user-defined variables conflicted with the control’s properties those all needed enough patience and logical ideas to resolve.

✧ Another difficulties or improvement are about how to find a useful way to deal with the problem in the communication part the author still keep on working and the inaccurate show value need to be correct as well.

4.4 Future development

4.4.1 Extended/Advanced functions on oscilloscope simulation

X-position changes

Changing the scales of the X-axis and Y-axis allows many different signals to be displayed. Sometimes, it is also useful to be able to change the position of the axes. This is possible using the **X-POS** and **Y-POS** controls. Owing to the limited time, only Y-POS have developed.

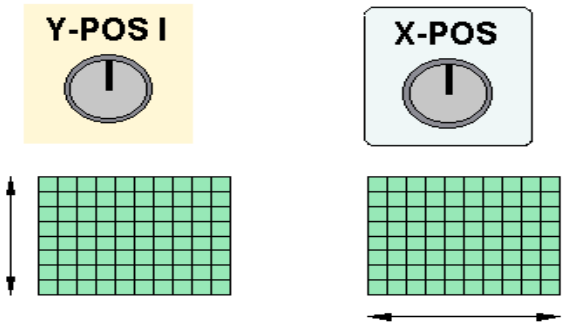


Figure 44 Y-POS vs X-POS [11]

Y-POS 1 moves the whole trace vertically up and down on the screen, while X-POS moves the whole trace from side to side on the screen. These controls are useful because the trace can be moved so that more of the picture appears on the screen, or to make measurements easier using the grid which covers the screen, for example, to measure the period of a waveform. [11]

Trigger

It is only needed if the spot moves at an angle rather than horizontally across the screen with no signal connected. The trigger circuit is used to delay the time base waveform so that the same section of the input signal is displayed on the screen each time the spot moves across. He, Miao / PC Oscilloscope USB based

The effect of this is to give a stable picture on the oscilloscope screen, making it easier to measure and interpret the signal. [11] On account of its function in real oscilloscope, the button control maybe can be added in the design interface and then add code in the code editor interface such as “usercontrol1.data = 20” that should work together with the ‘timer’ control due to delay the time base waveform.

Function generator

As shown in the results, by using different math functions the different traces can be spotted over screen. Adding button controls as a function generator to show different waves should be a feasible step. Like the real oscilloscope below:

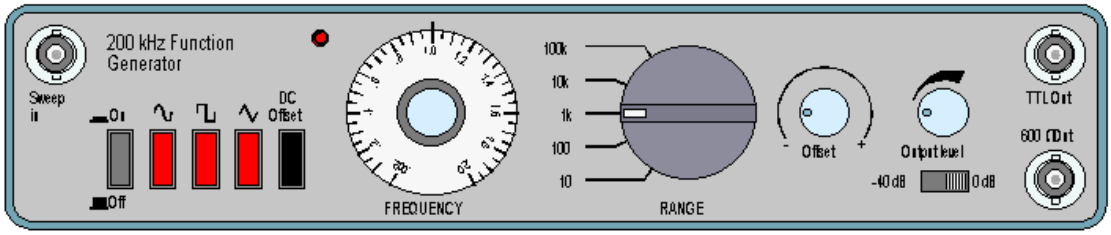


Figure 45 Function generator [11]

Dual trace

Maybe “Dual trace” can be realized by adding the other loop in the source code that should be similar with the data is plotted part. But, the programmers have to pay attention to the control of position and some related parameter changes of these two trace (Figure 46).

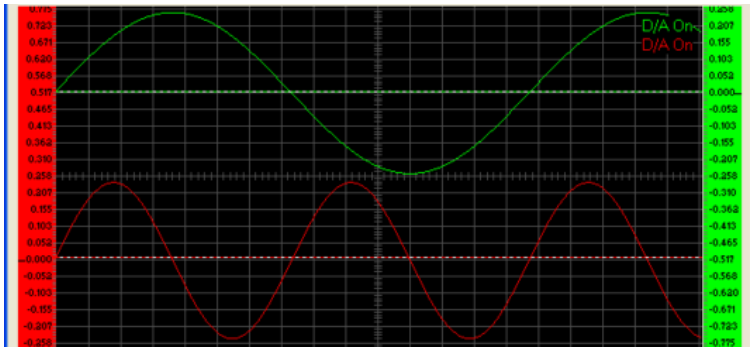


Figure 46 Dual trace

Certainly, other left controls in the oscilloscope can be added as well.

4.4.2 USB connectivity between PC & DSP

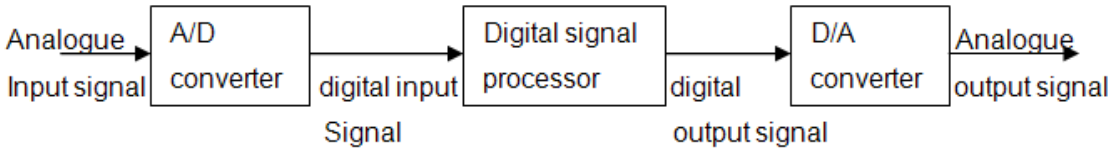


Figure 47 Block diagram a digital signal processing system [13]

Most of the signals encountered in science and engineering are analogue in nature. That is, the signals are functions of a continuous variable, such as time or space, and usually take on values in a continuous range. Such signals may be processed directly by appropriate systems. Digital signal processing provides an alternative method for processing the analogue signal, as illustrated in Figure 47. To perform the processing digitally, there is a need for an interface between the analogue signal and the digital processor. This interface is called an analogue-to-digital (A/D) converter. The output of the A/D converter is a digital signal that is appropriate as an input to the digital processor. The digital signal processor may be a large programmable digital computer or a small microprocessor programmed to perform the desired operations on the input signal. In applications the required output signal is another analogue output signal, which requires a digital to analogue converter. [13]

The architecture of a data acquisition system utilizing the processing capability of a DSP Chip is a common method. The great interest is the ability for users to stream fast data rates to a host in an economical way. The new standard of USB 2.0 allows high speed data transfer between such a DSP peripheral or standalone and a host PC.

For software design, the communication program for sending data to the USB module and the drivers for setting up the DAC channels should be developed. For hardware implementation, the Figure 48 provides the basic connection to a DSP board.

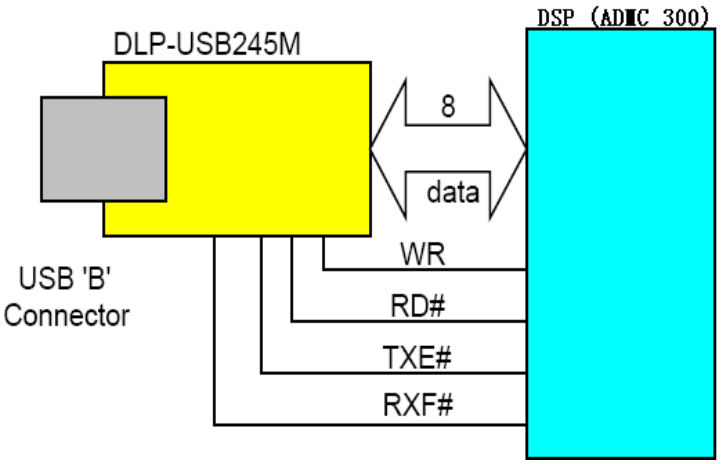


Figure 48 Basic connections to a DSP board [10]

Summary

This chapter provides concise conclusions on the project findings and major information of this report with further development.

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APPENDICES

APPENDICE A-Software: Source code & Test results

Source code

Part 1: On plotting data and oscilloscope simulation

```
‘ Globe variables definiation
      Public Class UserControl1
          Public Shared ReadSize = 4096
          Public Shared WriteSize As Integer = 4096
          ’ the counters statement for the realization of oscilloscope’s functions
          Dim i_stepup_count As Integer ’as a counter used for adjusting the position of
trace
          Dim i_stepdown_count As Integer
               Dim i_stepmove_right_count As Integer ’as a counter used for adjusting the
    time/div of trace
          Dim i_stepmove_left_count As Integer
          Dim offset, high, width1 As Integer ’ declare these three as globe/public
variables
          Dim m_startX, m_startY, m_endX, m_endY As Integer
          ’the range of the data shown
          Dim m_MaxValue, m_MinValue As Integer ’ data range for display
          Dim m_MaxXValue, m_MinXValue As Double ’text for showing the time/div
          Dim m_upValue, m_downValue As Double ’text for showing the value of position
               Dim m_DataPlot(1000) As Integer ’the data array ready for plotting &  more
        data plotted and more smooth of the curve
          Dim m_range, m_screen_range As Integer
          ’ the changeable portion for the controls like amplitude, time and position
          Dim dy As Double
          Dim dt As Double
          Dim da As Double
          Dim tmpPosUp As Integer = 0
          Dim tmpPosDow As Integer = 0
          ’declare variables for adding new properties
          Private cBackColor As Color = Color.Blue
          Private cLineColor As Color = Color.White
          Private iData As Integer = 0
          ’add a user event for updating array
        Private Event DataUpdate()
```

```
      ‘ Assign values to the globe variables
      Private Sub MainWin_Load(ByVal sender As System.Object, ByVal e As System.EventArgs)
      Handles MyBase.Load
      ’Gets or sets the size of the SerialPort input buffer and adjust the comport buffer
      and process the buffer when receiving data
              With SerialPort1
                  .ReadBufferSize = ReadSize
                  .WriteBufferSize = WriteSize
              End With
 ’ when in the designmode, the border line of the PicDataView(plotting region) & MainWin
should be shown
              If Me.DesignMode = True Then
                  Me.BorderStyle = Windows.Forms.BorderStyle.Fixed3D
                  PicDataView.BorderStyle = Windows.Forms.BorderStyle.Fixed3D
              End If
              ’define the number/amount of the data wanted to display currently at y axis
              m_MaxValue = 1000
```

```
            m_MinValue = -1000
            ' just used for display the value of x axis
            dt = 0.1
            m_MinXValue = 0
            m_MaxXValue = m_DataPlot.Length * dt
            SerialPort_setting.SerialPort1 = Me.SerialPort1 ' to insure the virtual serial
port can be shared between forms and user controls or this statement used to connect the
serialport_setting form and 'MainWin' control



        ' make the offset as public variable and define its initial value so that the
position control can work
            m_startX = 0
            m_startY = 0
            m_endX = PicDataView.Width ' find the PicDataView/screen region like canvas
            m_endY = PicDataView.Height
            high = m_endY - m_startY - 25 'the range of reference table (screen) / the
region for plotting
            width1 = m_endX - m_startX - 80
            offset = m_endY - (high / 2 + 20) 'make sure at the beginning of plotting data
at vertical middle point

        End Sub
```

```
'Add data property
'add the data as public property usd for plotting and tell the control when to receive data
instead of variable due to sometimes it should be globe not local
        Public Property data() As Integer
            Get
                'Data values are write only, no read.
            End Get
            Set(ByVal Value As Integer)
                iData = Value
                If Me.DesignMode = False Then
                    ' to raise an event I need to specify the raiseevent statement,
passing it the event name as well as the parameters for the event being raised.
                    RaiseEvent DataUpdate() ' if it is in the run mode call the dataupdate
event to update incoming data(put them in the array ready for plotting) and then plot them
                End If

            End Set
    End Property
```

```
'Update array
       'put the received data in the dataArray ready for plotting or data array update
        Private Sub MainWin_DataUpdate() Handles Me.DataUpdate
            Dim iDataCounter As Integer
            For iDataCounter = m_DataPlot.Length - 1 To 1 Step -1 'it can be changed to 1
to m_DataPlot.Length - 1 step 1 if like this, the sequence for plotting also should be
altered such as  For i = m_DataPlot.Length - 2  To 0 Step -1
            m_DataPlot(iDataCounter) = m_DataPlot(iDataCounter - 1)
            Next iDataCounter
            m_DataPlot(0) = iData ' put the incoming data in the zero position of the
m_dataplot
            TextBox1.Text = iData ' to shown the last data
            Me.Refresh()
    End Sub
```

```
'Use 'paint' event to draw data
        Private Sub MainWin_Paint(ByVal sender As Object, ByVal e As
System.Windows.Forms.PaintEventArgs) Handles Me.Paint
            'insure only at the run mode the data can be plotted
            If Me.DesignMode = False Then
                DrawData()
            End If
        End Sub
```

```
'Rescal the controls' size
        Private Sub MainWin_Resize(ByVal sender As Object, ByVal e As System.EventArgs)
Handles Me.Resize
            '  adjust it to work under activeX control or Windows Control component and
put in here code to rescale all the controlls on your form
            'when the activeX control is reuseable the size of it should be changed to
make all of the ActiveX control can be shown clearly
            If Me.DesignMode = True Then ' restrict the minimum size of the usercontrol1
                If Me.Width < 500 Then
                    Me.Width = 500
                End If
                If Me.Height < 450 Then
                    Me.Height = 450
                End If
                ' first define the position of the screen region/ plotting area and then
use it as a reference to control the other controls size and position
                PicDataView.Top = 5
                PicDataView.Left = 5
                PicDataView.Width = Me.Width - 200
                PicDataView.Height = Me.Height - 25
                Me.Refresh()
                Label1.Top = 35
                Label1.Left = PicDataView.Width + 27
                Label1.Width = 59
                Label1.Height = 12
                MaxValue.Top = 26
                MaxValue.Left = PicDataView.Width + 100
                MaxValue.Width = 75
                MaxValue.Height = 21
                ShowMax.Top = 57
                ShowMax.Left = PicDataView.Width + 20
                ShowMax.Width = 75
                ShowMax.Height = 20
                ShowMin.Top = 57
                ShowMin.Left = PicDataView.Width + 100
                ShowMin.Width = 75
                ShowMin.Height = 20
                Label2.Top = 97
                Label2.Left = PicDataView.Width + 27
                Label2.Width = 29
                Label2.Height = 12
                ShowTime.Top = 88
                ShowTime.Left = PicDataView.Width + 100
                ShowTime.Width = 75
                ShowTime.Height = 21
                DrawData.Top = 115
                DrawData.Left = PicDataView.Width + 20
                DrawData.Width = 75
                DrawData.Height = 20
                Button4.Top = 115
```

```
            Button4.Left = PicDataView.Width + 100
            Button4.Width = 75
            Button4.Height = 20
            Label3.Top = 154
            Label3.Left = PicDataView.Width + 27
            Label3.Width = 53
            Label3.Height = 12
            TextBox3.Top = 145
            TextBox3.Left = PicDataView.Width + 100
            TextBox3.Width = 75
            TextBox3.Height = 21
            upbutton.Top = 172
            upbutton.Left = PicDataView.Width + 20
            upbutton.Width = 75
            upbutton.Height = 20
            DownButton.Top = 172
            DownButton.Left = PicDataView.Width + 100
            DownButton.Width = 75
            DownButton.Height = 20
            DataRead.Top = 199
            DataRead.Left = PicDataView.Width + 20
            DataRead.Width = 75
            DataRead.Height = 20
            Label4.Top = 239
            Label4.Left = PicDataView.Width + 27
            Label4.Width = 65
            Label4.Height = 12
            TextBox1.Top = 254
            TextBox1.Left = PicDataView.Width + 20
            TextBox1.Width = 156
            TextBox1.Height = 21
            Label5.Top = 296
            Label5.Left = PicDataView.Width + 27
            Label5.Width = 95
            Label5.Height = 12
            SData.Top = 311
            SData.Left = PicDataView.Width + 20
            SData.Width = 156
            SData.Height = 21
            SendData.Top = 338
            SendData.Left = PicDataView.Width + 20
            SendData.Width = 75
            SendData.Height = 20
            Label6.Top = 359
            Label6.Left = PicDataView.Width + 27
            Label6.Width = 89
            Label6.Height = 12
            RData.Top = 374
            RData.Left = PicDataView.Width + 20
            RData.Width = 156
            RData.Height = 21
            Button5.Top = 413
            Button5.Left = PicDataView.Width + 20
            Button5.Width = 75
            Button5.Height = 20
        End If
    End Sub
```

```
    Private Sub SData_TextChanged(ByVal sender As System.Object, ByVal e As
```

```
System.EventArgs) Handles SData.TextChanged

        End Sub
```

```
'Send data to buffer and receive it from buffer
    Private Sub SendData_Click(ByVal sender As System.Object, ByVal e As System.EventArgs)
Handles SendData.Click
        SPDataSend()
    End Sub
```

```
        Sub SPDataSend() 'send data button
            If SerialPort1.IsOpen = False Then ' test the serialport open or not
                MessageBox.Show("The COM is not existing or occupying! ", "error",
MessageBoxButtons.OK, MessageBoxIcon.Error, MessageBoxDefaultButton.Button1)
                Exit Sub
            Else
                SerialPort1.Write(SData.Text) ' write data into the buffer
                SData.Text = "" ' show the written text
                RData.Text = SerialPort1.ReadExisting ' read data from the buffer but
there will be a limitation for receving.
            End If
        End Sub
```

```
        Private Sub RData_TextChanged(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles RData.TextChanged

        End Sub
```

```
'Alternatively, use 'OpenFileDialog' to acess data
    Private Sub DataRead_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles DataRead.Click
        Dim m_DataFile As String
        OpenFileDialog1.ShowDialog()
        m_DataFile = OpenFileDialog1.FileName
    End Sub
```

```
'Zoom out trace
    Private Sub ShowMax_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles ShowMax.Click
        ' here for zoomming out
        m_MaxValue = m_MaxValue * 0.9
        m_MinValue = m_MinValue * 0.9
        MaxValue.Text = m_MaxValue
        PicDataView.Refresh()
        DrawData()
    End Sub
```

```
'Zoom in trace
    Private Sub ShowMin_Click(ByVal sender As System.Object, ByVal e As System.EventArgs)
Handles ShowMin.Click
        ' here for zoomming in
        m_MaxValue = m_MaxValue * 1.1
        m_MinValue = m_MinValue * 1.1
        MaxValue.Text = m_MaxValue
        PicDataView.Refresh() ' do not want the changable values covered each other
        DrawData()
```

```
        End Sub
        ' in fact real function of time/div is changeable array locations for plotting but
the program here is not.
        Private Sub DrawData_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles DrawData.Click
            Dim dx As Double
            i_stepmove_right_count = i_stepmove_right_count + 1
            For t = 1 To 1000
                m_DataPlot(t) = -500 * Math.Sin(Math.PI * t / (1000 /
i_stepmove_right_count))
            Next t
            dx = 2 * Math.PI / (10 * 2 / i_stepmove_right_count)
            m_MinXValue = dx
            i_stepmove_left_count = 0
            ShowTime.Text = m_MinXValue ' show the maxmum time or min time
            PicDataView.Refresh() ' using refresh to advoid the value of time overlapping
when the time is changeable
            DrawData() ' call the subroutine of drawdata
        End Sub
```

```
        Private Sub Button4_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles Button4.Click
            Dim dx1 As Double
            i_stepmove_left_count = i_stepmove_left_count + 1
            If i_stepmove_left_count > 8 Then ' control the minimum waveform plotted in
the screen to make it look clearly
                i_stepmove_left_count = 8
            End If
            For t = 1 To 1000
                m_DataPlot(t) = -500 * Math.Sin(Math.PI * t / (i_stepmove_left_count *
125))
            Next t
            dx1 = 2 * Math.PI / (10 * i_stepmove_left_count / 4) '1 / (i_stepmove_count *
125)
            m_MinXValue = dx1
            i_stepmove_right_count = 0
            ' m_MaxXValue -= dx1
            ShowTime.Text = m_MinXValue
            'ShowTime.Text = m_MaxXValue
            PicDataView.Refresh()
            DrawData()
        End Sub
```

```
'Key program for plotting data
        Sub DrawData()
            m_startX = 0
            m_startY = 0
            m_endX = PicDataView.Width ' find the region of PicDataView/screen like canvas
            m_endY = PicDataView.Height
            'plot the border of reference table or the region for plotting
            'Sets gr to a Graphics object representing the drawing surface of the control
or form gr is a member of.
            'Call the CreateGraphics method of the form or control upon which want to
render graphics
            Dim gr As Graphics = PicDataView.CreateGraphics
            'Draw the border of screen
            gr.DrawLine(Pens.White, 70, 5, 70, m_endY - 20)
            gr.DrawLine(Pens.White, 70, m_endY - 20, m_endX - 10, m_endY - 20)
            gr.DrawLine(Pens.White, m_endX - 10, m_endY - 20, m_endX - 10, 5)
            gr.DrawLine(Pens.White, m_endX - 10, 5, 70, 5)
```

```
            'plot the every square/ divisions of the table used to measure the value of
the curve like background of oscilloscope
            high = m_endY - m_startY - 25  'the range of reference table/ the region for
plotting
            width1 = m_endX - m_startX - 80
            Dim m_Vnum, m_Hnum As Integer
            m_Vnum = high / 10 'divide the PicDataView by 10 and each part is equal
            m_Hnum = width1 / 10
            Dim i As Integer  ' draw the lines from top to bottom & from left to right
            For i = 1 To 9
                gr.DrawLine(Pens.White, m_startX + 70, m_startY + 5 + (i * m_Vnum), m_endX
- 10, m_startY + 5 + (i * m_Vnum))
            Next
            For i = 1 To 9
                gr.DrawLine(Pens.White, m_startX + 70 + i * m_Hnum, m_startY + 5, m_startX
+ 70 + i * m_Hnum, m_endY - 20)
            Next
            range_change() 'the scaling of y-axis
            Dim m_xMiV, m_xMxV, m_yMxV, m_yMiV, m_uMxV As String
            'draw the text for diaplaying the amplitude,time and position
            Dim dx As Double
            m_yMxV = CStr(m_MaxValue) ' due to some of them are globe variables do not
want to be confused and then change to another name
            m_yMiV = CStr(m_MinValue)
            m_xMiV = CStr(m_MinXValue)
            m_xMxV = CStr(m_MaxXValue)
            m_uMxV = CStr(m_upValue)
            'm_dMiV = CStr(m_downValue)
            'Draws the specified text string at the specified location with the specified
Brush and Font objects
            gr.DrawString(m_yMxV, Me.Font, Brushes.Yellow, 30, 5) ' write the value at the
front and end of the table use to present the amplitude and time of the waveform also alter
as the waveform change
            gr.DrawString(m_yMiV, Me.Font, Brushes.Yellow, 30, 390)
            gr.DrawString(m_xMiV, Me.Font, Brushes.Yellow, 68, 405)
            gr.DrawString(m_xMxV, Me.Font, Brushes.Yellow, 458, 405)
            gr.DrawString(m_uMxV, Me.Font, Brushes.Yellow, 30, 197.5)
            'gr.DrawString(m_dMiV, Me.Font, Brushes.Yellow, 30, 197.5)
            Dim x1, x2, y1, y2 As Integer

            'offset = m_endY - (high / 2 + 20)

            dx = CDbl(width1) / (m_DataPlot.Length - 1) ' the scaling of x or every step
of x axis
            ' only utilize the dx & dy the sine-curve can be zoom in and zoom out as the
size of screen changes

            ' This is the data are plotted on the screen.current value(x1,y1) next value
(x2,y2)
            x1 = m_startX + 70 ' 'define the current value of x
            For i = 0 To m_DataPlot.Length - 2 Step 1
                y1 = offset + m_DataPlot(i) * dy ' define the current value of y
                x2 = m_startX + 71 + i * dx ' define the next value
                y2 = offset + m_DataPlot(i + 1) * dy
                If y1 > m_endY - 20 Then y1 = m_endY - 20
                If y1 < m_startY + 5 Then y1 = m_startY + 5
                If y2 > m_endY - 20 Then y2 = m_endY - 20
                If y2 < m_startY + 5 Then y2 = m_startY + 5 ' In order to guarantee the
value of y that beyond the reference table range when the curve zoom in can not be shown in
```

```
the screen
                    gr.DrawLine(Pens.White, x1, y1, x2, y2)
                    x1 = x2
                Next i
            End Sub
```

```
            Sub range_change() 'define the data and show the current value
                m_range = m_MaxValue - m_MinValue 'the amount of data wanted to show currently
in the y axis
                m_screen_range = m_endY - m_startY - 25 ' the range of display window in y
axis / the display region in the window of data display
                dy = m_screen_range / m_range ' dr=CDbl(high)/m_range the resolution of
between unit pixel in the region of window display or the scaling of y-axis
            End Sub
```

```
            Dim t As Integer
```

```
'Trace goes up
        Private Sub upbutton_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles upbutton.Click
                updata()
                da = m_endY - (high / 2 + 20) - tmpPosUp + tmpPosDow ' this is not exactly
value now shoud check it .
                m_upValue += da
                TextBox3.Text = m_upValue
                PicDataView.Refresh()
                DrawData()
        End Sub
```

```
            Sub updata()
                If offset > 100 Then ' choose the offset value to control the sine-curve can
not disappear from the plotting region when using the 'up' button
                    i_stepup_count = i_stepup_count + 1 ' i_stepup_count as a counter & every
time add "1" to make the curve go up step by step
                    tmpPosUp = tmpPosUp + i_stepup_count * 20 ' the variable-tmpPosUp stands
for the changeable portion
                    offset = m_endY - (high / 2 + 20) - tmpPosUp + tmpPosDow ' due to all the
data to plot using sine model based on the offset point  the other points in the curve
change as the offset changes
                    '+ tmpPosDow means from this position when the curve wants to go up in
that case to avoid the step jump
                End If
                i_stepdown_count = 0 'in that case to avoid the step jump because every time
finish the 'up' function and convert to the 'down' button should be from the start
        End Sub
```

```
        Private Sub Button5_Click(ByVal sender As System.Object, ByVal e As System.EventArgs)
Handles Button5.Click
                SerialPort_setting.Show() ' display the another window for USB setting cosist
of the COMPORT configuraion & communication backchannel between USB & PC
            End Sub
```

```
'Trace goes down
        ' this part for "down" position control similarly as "up" before
            Private Sub DownButton_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles DownButton.Click
                downdata()
                da = m_endY - (high / 2 + 20) + tmpPosDow - tmpPosUp
                m_upValue -= da
                TextBox3.Text = m_upValue
                PicDataView.Refresh()
                DrawData()
        End Sub
```

```
        Sub downdata()
            If offset < (m_endY - 100) Then
                i_stepdown_count = i_stepdown_count + 1
                tmpPosDow = tmpPosDow + i_stepdown_count * 20
                offset = m_endY - (high / 2 + 20) - tmpPosUp + tmpPosDow
            End If
            i_stepup_count = 0
    End Sub
```

```
'Add new properties for user control
        'add the property for background color for plotting region in case the user wants to change the color when using this system because customs can not see the design interface
        Public Property PicGraph_color() As Color
            Get
                Return cBackColor
            End Get
            Set(ByVal Value As Color)
                cBackColor = Value
                PicDataView.BackColor = cBackColor
            End Set
    End Property
```

```
        Public Property PicGraph_Line() As Color
            Get
                Return cLineColor
            End Get
            Set(ByVal Value As Color)
                cLineColor = Value
            End Set
        End Property
```

```
        Private Sub SerialPort1_DataReceived(ByVal sender As System.Object, ByVal e As System.IO.Ports.SerialDataReceivedEventArgs) Handles SerialPort1.DataReceived

        End Sub
    End Class
```

Part 2: Serial Port setting

```
    Public Class usbdriver
        Public Shared ReadSize = 4096
        Public Shared WriteSize As Integer = 4096
        Dim SPPause As Boolean = False
        Dim SPClose As Boolean = False
        Dim Datareceived(4096) As Integer '(4096) As Integer
        Dim USBarray(4096) As Byte ' the buffer in pc
        Private Event DataUpdate1()
```

```
        Private Sub usbdriver_Load(ByVal sender As System.Object, ByVal e As System.EventArgs) Handles MyBase.Load
            Alart_Init()
            System_Init()
            'Gets or sets the size of the SerialPort input buffer.adjust the comport buffer and process the buffer when receiving data
            With SerialPort1
                .ReadBufferSize = ReadSize
                .WriteBufferSize = WriteSize
            End With
```

```
            Me.SerialPort1 = SerialPort_setting.SerialPort1 'use to realize the serial
port shared between the user controls and the forms
        End Sub
```

```
        Sub System_Init()
            'the initialization of the comport
            CombSerPort.Items.Add("COM1")
            CombSerPort.Items.Add("COM2")
            CombSerPort.Items.Add("COM3")
            CombSerPort.Text = "COM1"
            'the initialization of the baudrate 'bit per second
            CombBaudRat.Items.Add(1200)
            CombBaudRat.Items.Add(2400)
            CombBaudRat.Items.Add(4800)
            CombBaudRat.Items.Add(9600) ' at 9600bps, a bit is 0.1 millisecond
            CombBaudRat.Items.Add(19200)
            CombBaudRat.Items.Add(38400)
            CombBaudRat.Text = 9600
            'the initialization of the parity
            CombParity.Items.Add("NONE")
            CombParity.Items.Add("ODD")
            CombParity.Items.Add("EVEN")
            CombParity.Text = "NONE"
            'the initialization of the databits
            CombDataBits.Items.Add(5)
            CombDataBits.Items.Add(6)
            CombDataBits.Items.Add(7)
            CombDataBits.Items.Add(8)
            CombDataBits.Text = 8
            'the initialization of the stopbits
            CombStopBits.Items.Add(1)
            CombStopBits.Items.Add(2)
            CombStopBits.Text = 1

        End Sub
```

```
        Sub InitSerialPort()
            With SerialPort1
                Try
                    Select Case CombSerPort.Text   'the select of COM
                        Case "COM1"
                            If .PortName <> "COM1" Then
                                .Close()
                                .PortName = "COM1"
                                .Open()
                            Else
                                Exit Select
                            End If
                        Case "COM2"
                            If .PortName <> "COM2" Then
                                .Close()
                                .PortName = "COM2"
                                .Open()
                            Else
                                Exit Select
                            End If
                        Case "COM3"
                            If .PortName <> "COM3" Then
                                .Close()
                                .PortName = "COM3"
```

```
                                .Open()
                            Else
                                Exit Select
                            End If

                        End Select
                    Catch ex As Exception
                        MessageBox.Show("The COM is not existing or occupying! ", "error",
MessageBoxButtons.OK, MessageBoxIcon.Error, MessageBoxDefaultButton.Button1)
                        PicAlart.BackColor = Color.Red
                        Exit Sub
                    End Try
                    Select Case CombBaudRat.Text   'the configuration of BaudRate
                        Case "1200"
                            .BaudRate = 1200
                        Case "2400"
                            .BaudRate = 2400
                        Case "4800"
                            .BaudRate = 4800
                        Case "9600"
                            .BaudRate = 9600
                        Case "19200"
                            .BaudRate = 19200
                        Case "38400"
                            .BaudRate = 38400
                    End Select
                    Select Case CombParity.Text 'the configuration of Parity
                        Case "NONE"
                            .Parity = IO.Ports.Parity.None
                        Case "ODD"
                            .Parity = IO.Ports.Parity.Odd
                        Case "EVEN"
                            .Parity = IO.Ports.Parity.Even
                    End Select
                    Select Case CombDataBits.Text
                        Case "5"
                            .DataBits = 5
                        Case "6"
                            .DataBits = 6
                        Case "7"
                            .DataBits = 7
                        Case "8"
                            .DataBits = 8
                    End Select
                    Select Case CombStopBits.Text ' the configuration of stopbits
                        Case "1"
                            .StopBits = IO.Ports.StopBits.One
                        Case "1.5"
                            .StopBits = IO.Ports.StopBits.OnePointFive
                        Case "2"
                            .StopBits = IO.Ports.StopBits.Two
                    End Select
                End With
                'begin to receive data
                Try
                    With SerialPort1
                        .Encoding = System.Text.Encoding.ASCII
                        .DiscardInBuffer()
                        .ReceivedBytesThreshold = 1
```

```
                End With
            Catch ex As Exception
                MessageBox.Show("The COM is not existing or occupying! ", "error",
MessageBoxButtons.OK, MessageBoxIcon.Error, MessageBoxDefaultButton.Button1)
                PicAlart.BackColor = Color.Red
                Exit Sub
            End Try
        End Sub ' Serial Port setting Part 2: reference available at Programming Serial
Ports Using Visual Basic 2005 http://www.devx.com/dotnet/Article/31001/0/page/1
```

```
        Private Sub OpenSerPort_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles OpenSerPort.Click
            OpenSerialPort()
    End Sub
```

```
        Sub OpenSerialPort()
            If SerialPort1.IsOpen = False Then
                Try
                    SerialPort1.Open()
                Catch ex As Exception
                End Try
            End If
            InitSerialPort()
            If SerialPort1.IsOpen = True Then
                PicAlart.BackColor = Color.Green ' use the green color to indicate the
comport is open
            End If

        End Sub
```

```
        Private Sub ClosSerPort_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles ClosSerPort.Click
            CloseSerialPort()
    End Sub
```

```
        Sub CloseSerialPort()
            If SerialPort1.IsOpen = True Then
                SerialPort1.DiscardInBuffer() ' if the serial port close, it should
discard the buffer to avoid waste resource
                SerialPort1.DiscardOutBuffer()
                Try
                    SerialPort1.Close()
                Catch ex As Exception
                End Try
            End If
            If SerialPort1.IsOpen = False Then
                PicAlart.BackColor = Color.Red
            End If
    End Sub
```

```
        Sub Alart_Init()
            PicAlart.BackColor = Color.Red
        End Sub
```

```
'Communication programming between USB and PC
    '1: add the IInputData for communication part 2: update the data array 3: process the
received data
        'this part have some problem now should keep on working.
        Public Property IInputData() As Integer
            Get
```

```
                Datareceived(4096) = SerialPort1.ReadExisting
                If Me.DesignMode = False Then
                    RaiseEvent DataUpdate1()
                End If
            End Get
            Set(ByVal Value As Integer)
                Datareceived(4096) = Value
            End Set
        End Property
```

```
        Private Sub MainWin_DataUpdate1() Handles Me.DataUpdate1
            Dim iDataCounter As Integer
            For iDataCounter = USBarray.Length - 1 To 1 Step -1
                USBarray(iDataCounter) = USBarray(iDataCounter - 1)
            Next iDataCounter
            Dim i As Integer
            For i = 1 To 4096 Step 1
                USBarray(0) = Datareceived(i)
            Next i
            Me.Refresh()
        End Sub
```

```
        Private Sub SerialPort1_DataReceived(ByVal sender As Object, ByVal e As
System.IO.Ports.SerialDataReceivedEventArgs) Handles SerialPort1.DataReceived
            'processing of the recieved data
            Dim i As Integer
            Datareceived(i) = SerialPort1.Read(USBarray, 0, 4095)
            For i = 1 To 1000 '4096 / 2 Step 1
                Datareceived(i) = (256 * USBarray(i * 2) + USBarray((i * 2) + 1)) 'invert
the 8bits to 16 bits
            Next i
        End Sub

    End Class
```

Part 3: using sine function to draw trace (support the run interface)

```
    Public Class Form1
        Dim Datareceived(1000) As Integer
```

```
        Private Sub UserControl11_Load(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles UserControl11.Load
        End Sub
```

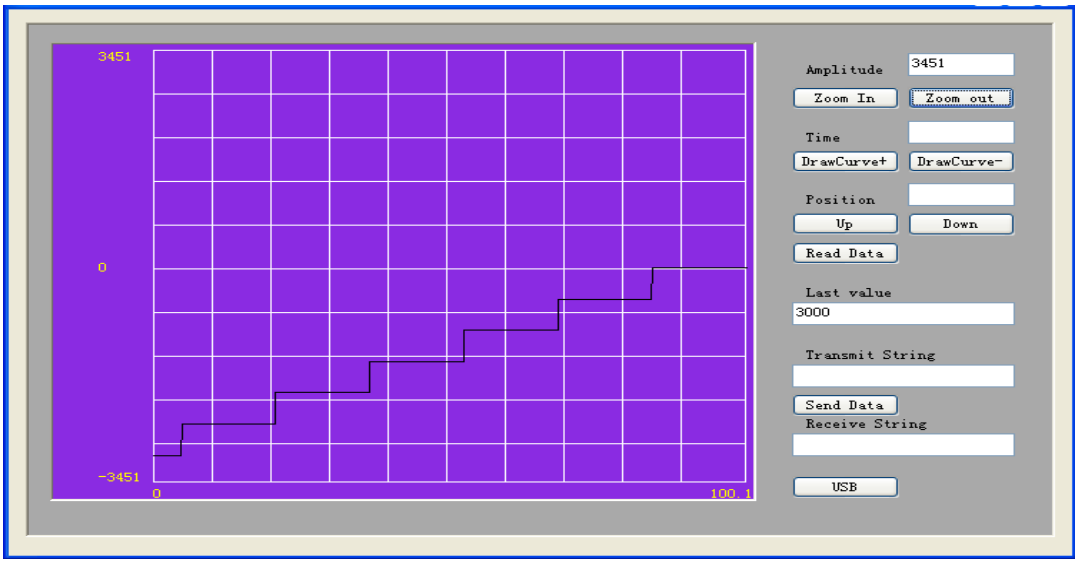
```
        Private Sub Form1_Load(ByVal sender As System.Object, ByVal e As System.EventArgs)
Handles MyBase.Load

            'UserControl11.PicGraph_color = Color.BlueViolet
            UserControl11.PicGraph_Line = Color.White
            Dim t As Integer

            For t = 1 To 1000 ' t must be greater or equal to the plotting location.
                Datareceived(t) = 500 * Math.Sin(Math.PI * t / 250) ' /250 means there
should be ploted two cycles in the screen /500 stands for one cycle.

            Next
            For t = 1 To 1000
                UserControl11.data() = Datareceived(t)
            Next t
        End Sub
```

```
End Class
```

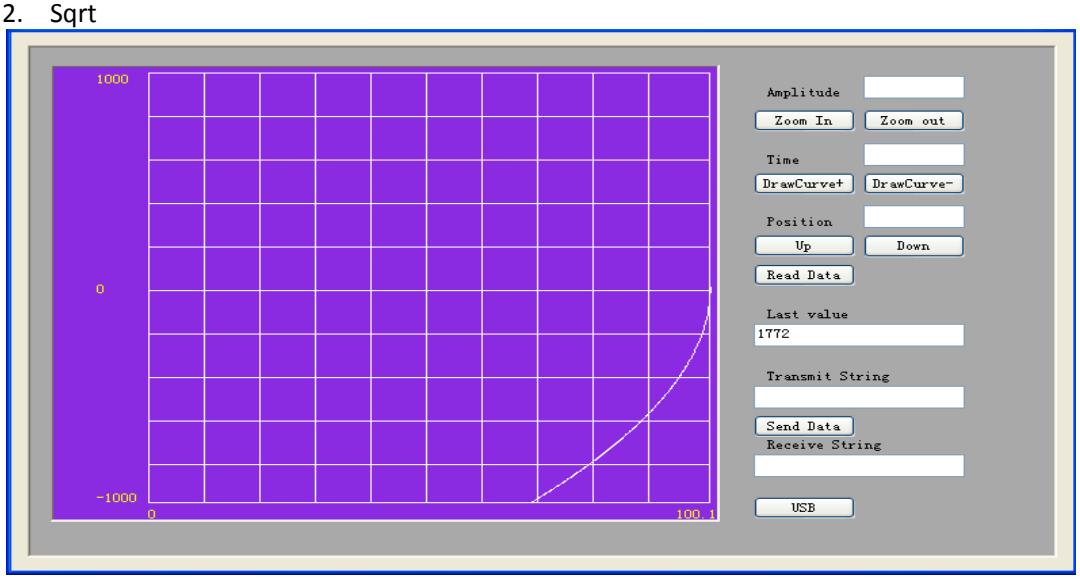
Test results

Different traces

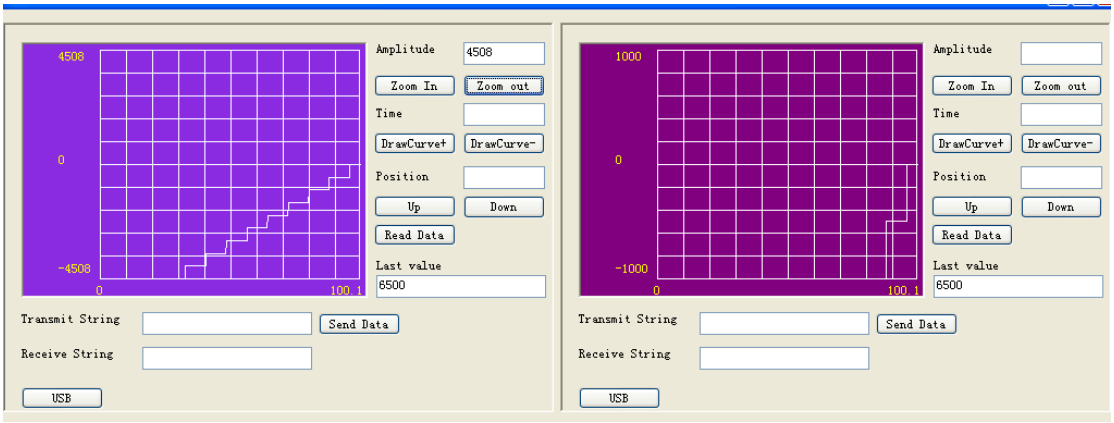
1. Truncate



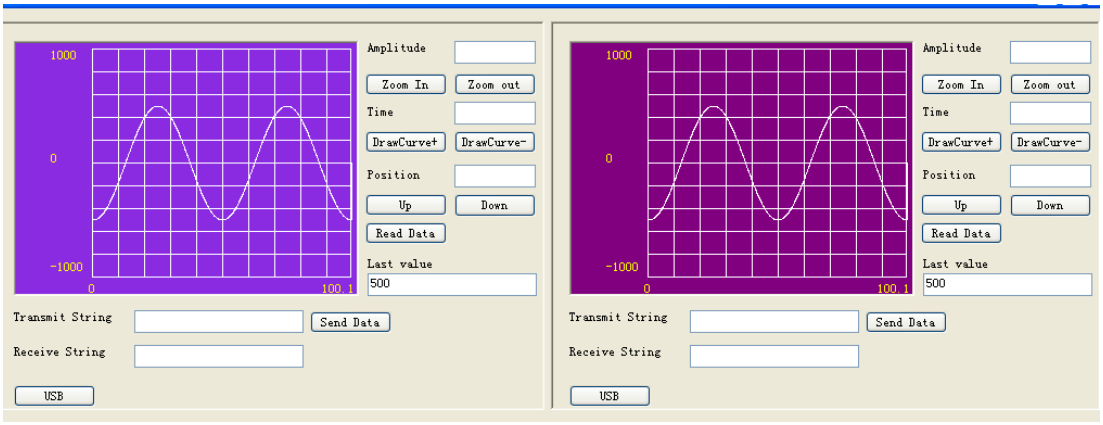
2. Sqrt



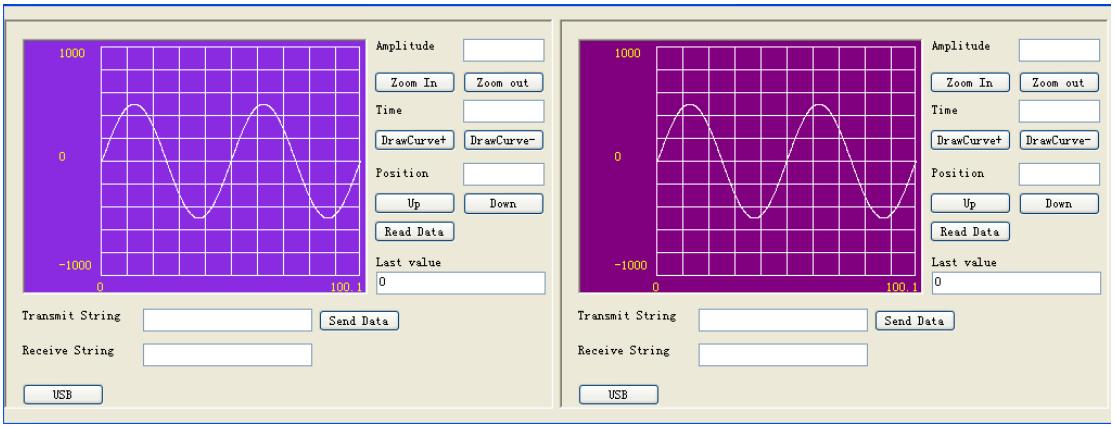
3. Round



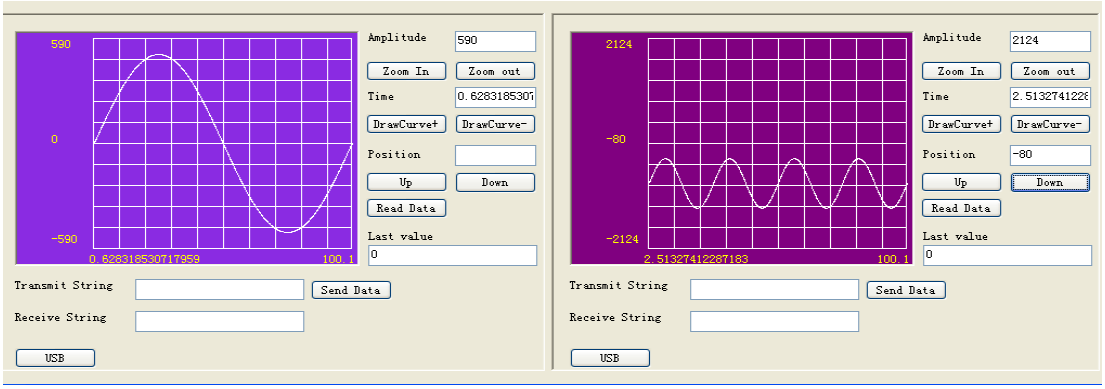
4. Cos



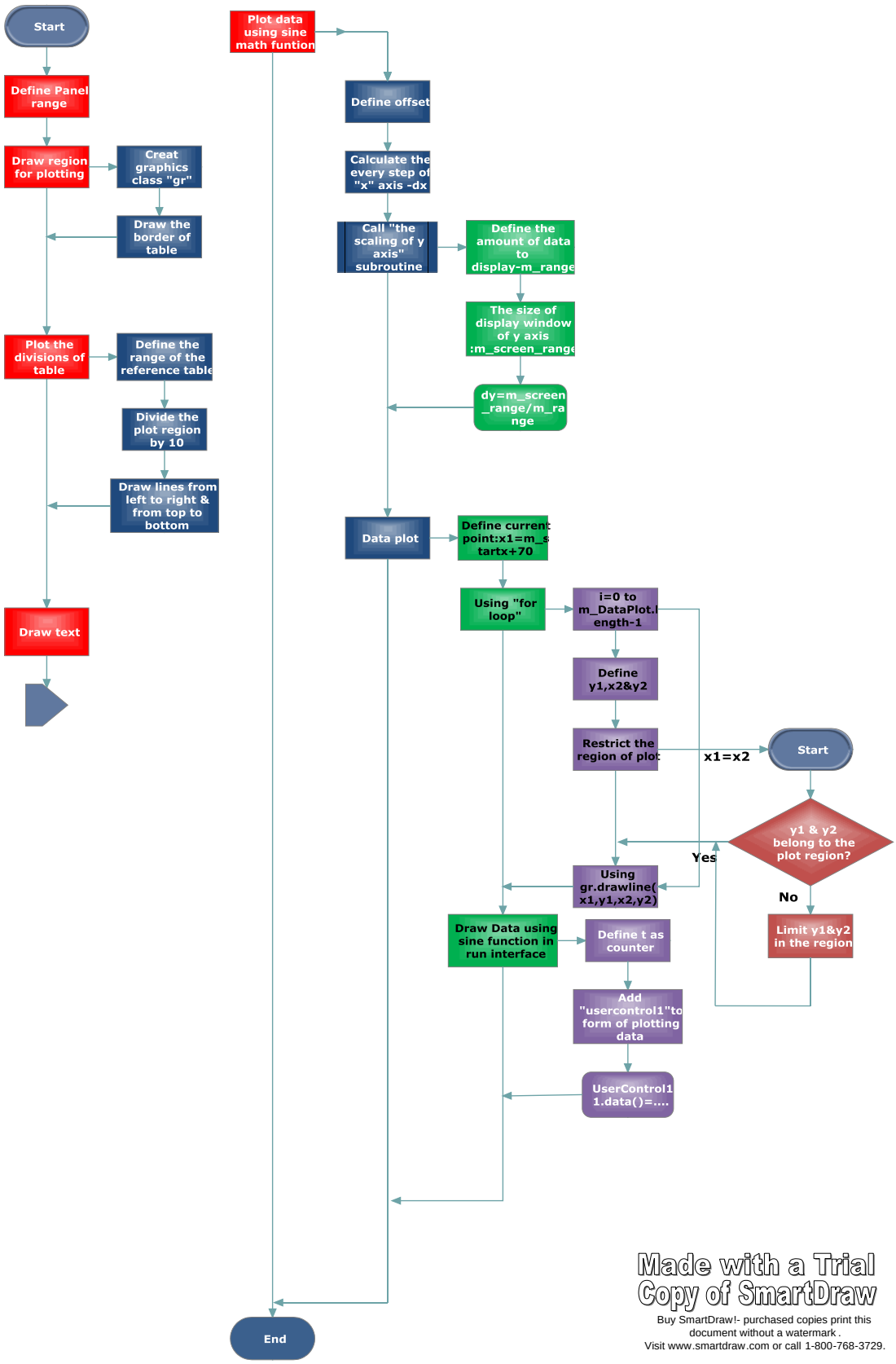
Active X control reusable in the run interface



The controls like amplitude or time also can be adjusted shown as figure below.



The program structure for plotting data:

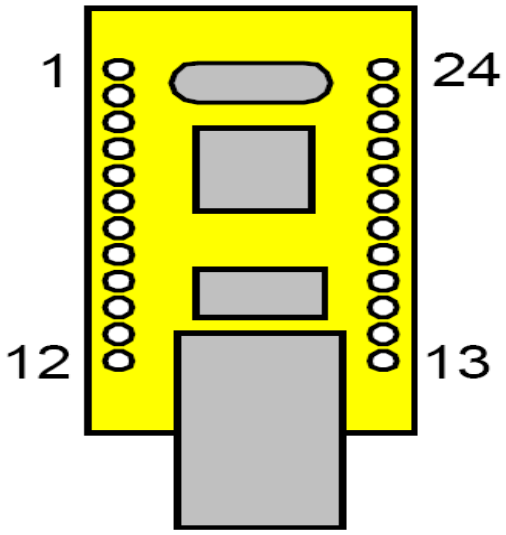


APPENDICE B-Hardware: DLP-USB 245M Adapter

Available at data sheet of USB module (reference [11])

- **Pin number and description**

Table 1 - DLP-USB245M PINOUT DESCRIPTION



Pin#	Description
1	**BOARD ID** (Out) Identifies the board as either a DLP-USB245M or DLP-USB232M. High for DLP-USB232M and low for DLP-USB245M.
2	**Ground**
3	**RESET#** (In) Can be used by an external device to reset the FT245BM. If not required this pin must be tied to VCC.
4	**RESETO#** (Out) Output of the internal Reset Generator. Stays high impedance for ~ 2ms after VCC > 3.5v and the internal clock starts up, then clamps it's output to the 3.3v output of the internal regulator. Taking RESET# low will also force RSTOUT# to go high impedance. RSTOUT# is NOT affected by a USB Bus Reset.
5	**Ground**
6	**3V3OUT** (Out) Output from the integrated L.D.O. regulator. It's primary purpose is to provide the internal 3.3v supply to the USB transceiver cell and the RSTOUT# pin. A small amount of current (<= 5mA) can be drawn from this pin to power external 3.3v logic if required.
7	**Ground**
8	**SLEEP** (Out) Goes Low after the device is configured via USB, then high during USB suspend. Can be used to control power to external logic using a P-Channel Logic Level MOSFET switch.
9	**SND/WUP** (In) If the DLP-USB245M is in USB suspend, a positive edge on this pin (WAKEUP) initiates a remote wakeup sequence. If the device is active (not in suspend) a positive edge on this pin (SEND) causes the data in the write buffer to be sent to the PC on the next USB Data-In request regardless of how many bytes are in the buffer.

10	**VCC-IO** (In) 3.0 volt to +5.25 volt VCC to the UART interface pins 10..12, 14..16 and 18..25. When interfacing with 3.3v external logic connect VCC-IO to the 3.3v supply of the external logic, otherwise connect to VCC to drive out at 5v CMOS level. This pin must be connected to VCC from the target electronics or EXTVCC.
11	**EXTVCC** – (In) Use for applying main power (4.4 to 5.25 Volts) to the module. Connect to PORTVCC if module is to be powered by the USB port (typical configuration)
12	**PORTVCC** - (Out) Power from USB port. Connect to EXTVCC if module is to be powered by the USB port (typical configuration). 500mA maximum current available to USB adapter and target electronics if USB device is configured for high power.
13	**RXF# -** (Out) When low, at least 1 byte is present in the FIFO's 128-byte receive buffer and is ready to be read with RD#. RXF# goes high when the receive buffer is empty.
14	**TXE#** - When high, the FIFO's 385 byte transmit buffer is full, or busy storing the last byte written. Do not attempt to write data to the transmit buffer when TXE# is high.
15	**WR** (In) When taken from a high to a low state, WR reads the 8 data lines and writes the byte into the FIFO's transmit buffer. Data written to the transmit buffer is sent to the host PC within the TX buffer timeout value (default 16mS) and placed in the RS-232 buffer opened by the application program. Note : The FT245BM allows the TX buffer timeout value to be reprogrammed to a value between 1 and 255mS depending on the applicaton requirement, also the SND pin can be used to send any remaining data in the TX buffer regardless of the timeout value.
16	**RD#** (In) When pulled low, RD# takes the 8 data lines from a high impedance state to the current byte in the FIFO's receive buffer. Taking RD# high returns the data pins to a high impedance state and prepares the next byte (if available) in the FIFO to be read.
17	**D7** I/O Bi-directional Data Bus Bit # 7
18	**D6** I/O Bi-directional Data Bus Bit # 6
19	**D5** I/O Bi-directional Data Bus Bit # 5
20	**D4** I/O Bi-directional Data Bus Bit # 4
21	**D3** I/O Bi-directional Data Bus Bit # 3

- **DC Characteristics (Ambient Temperature = 0 .. 70oC)**

Electrical level

Operating Voltage and Current

Parameter	Description	Min	Typ	Max	Units	Conditions
Vcc1	VCC Operating Supply Voltage	4.4	5.0	5.25	V	
Vcc2	VCCIO Operating Supply Voltage	3.0	-	5.25	V	
Icc1	Operating Supply Current	-	25	-	mA	Normal Operation
Icc2	Operating Supply Current	-	350	400	uA	USB Suspend

FIFO IO Pin Characteristics (VCCIO = 5.0v)

Parameter	Description	Min	Typ	Max	Units	Conditions
Voh	Output Voltage High	4.4	-	4.9	V	I source = 2mA
Vol	Output Voltage Low	0.1	-	0.7	V	I sink = 4 mA
Vin	Input Switching Threshold	1.1	1.5	1.9	V	Note 1
VHys	Input Switching Hysteresis		200		mV	

FIFO IO Pin Characteristics (VCCIO = 3.3v)

Parameter	Description	Min	Typ	Max	Units	Conditions
Voh	Output Voltage High	2.7	-	3.2	V	I source = 2mA
Vol	Output Voltage Low	0.1	-	0.7	V	I sink = 4 mA
Vin	Input Switching Threshold	1.0	1.4	1.8	V	Note 1
VHys	Input Switching Hysteresis		200		mV	

RESET# Pin Characteristics

Parameter	Description	Min	Typ	Max	Units	Conditions
Vin	Input Switching Threshold	1.1	1.5	1.9	V	Note 3
VHys	Input Switching Hysteresis		200		mV	

RSTOUT Pin Characteristics

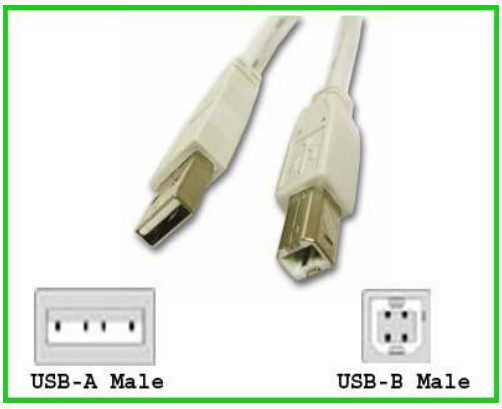
Parameter	Description	Min	Typ	Max	Units	Conditions
Voh	Output Voltage High	3.0	-	3.6	V	I source = 2mA
Iol	Leakage Current Tri-State	-	-	5	uA	

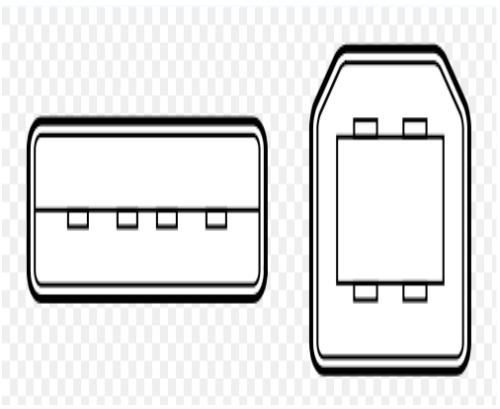
USB IO Pin Characteristics

Parameter	Description	Min	Typ	Max	Units	Conditions
UVoh	IO Pins Static Output (High)	2.8		3.6v	V	RI = 1k5 to 3V3Out (D+) RI = 15k to GND (D-)
UVol	IO Pins Static Output (Low)	0		0.3	V	RI = 1k5 to 3V3Out (D+) RI = 15k to GND (D-)
UVse	Single Ended Rx Threshold	0.8		2.0	V	
UCom	Differential Common Mode	0.8		2.5	V	
UVDif	Differential Input Sensitivity	0.2			V	
UDrvZ	Driver Output Impedance	29		44	ohm	Note 4

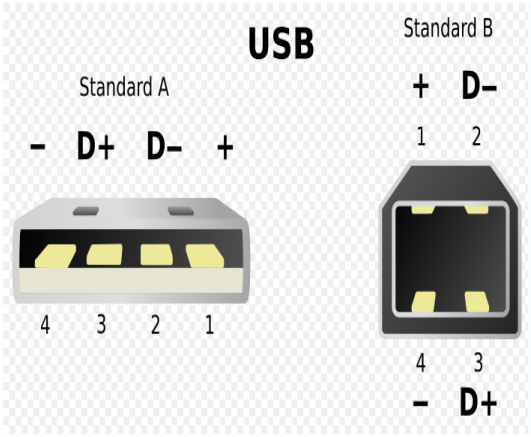
APPENDICE C-Hardware Accessories: USB cable & Bread-Board

There are several types of USB connectors, and some have been added as the specification has progressed. The original USB specification detailed Standard-A and Standard-B plugs and receptacles. The first engineering change notice to the USB 2.0 specification added Mini-B plugs and receptacles.





Type A (left) and Type B (right) USB connectors



Pin	Name	Cable colour	Description
1	VCC	Red	+5V
2	D−	White	Data −
3	D+	Green	Data +
4	GND	Black	Ground

Pin configuration of the USB connectors Standard A/B, viewed from face of plug

Figure A-1 USB cable

The USB specification provides a 5 V supply on a single wire from which connected USB devices may draw power. The host operating system typically keeps track of the power requirements of the USB network and may warn the computer's operator when a given segment requires more power than is available.

The bread board has many strips of metal (copper usually) which run underneath the board. The metal strips are laid out as shown below (right). These strips connect the holes on the top of the board. This makes it easy to connect components together to build circuits. To use the bread board, the legs of components are placed in the holes. The holes are made so that they will hold the component in place. Each hole is connected to one of the metal strips running underneath the hole. [1]

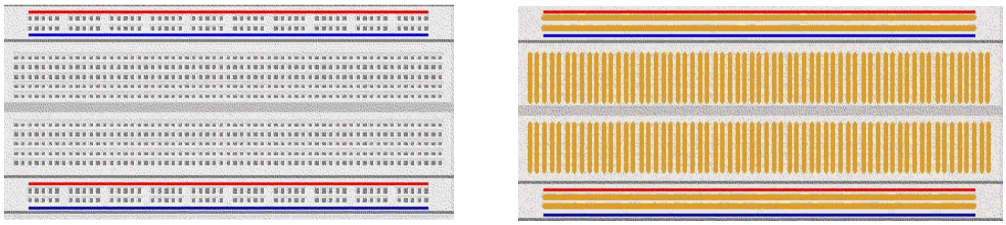


Figure A-2 Bread Board [1]

Each strip forms a node. A node is a point in a circuit where two components are connected. Connections between different components are formed by putting their legs in a common node. On the bread board, a node is the row of holes that are connected by the strip of metal underneath. [1]

The long top and bottom row of holes are usually used for power supply connections. The row with the blue strip beside it is used for the negative voltage (usually ground) and the row with the red strip beside it is used for the positive voltage. The circuit is built by placing components and connecting them together with jumper wires. Then when a path is formed from the positive supply node to the negative supply node through wires and components, we can turn on the power and current flows through the path and the circuit comes alive. [1]

[1] Title: using the bread board available at http://www.iguanalabs.com/breadboard.htm

APPENDICE D-Revised Gantt chart

	TASK NAME	SD	ED	Duration
A	**Project Specification**	10.10.07	17.10.07	1w
B	**Feasibility study**			
	• Literature research	10.10.07	31.10.07	3w
	• Understand Background information	10.10.07	31.10.07	3w
	• Write feasibility report	24.10.07	31.10.07	1.5w
	• Read past report	17.10.07	03.11.07	2.5w
C	**Analysis and Understanding**			
	• Design Block diagram of system	03.11.07	14.11.07	1.5w
D	**Study and Review**			
	• Visual basic 2005	14.11.07	31.01.08	7w
	• operation and architecture of USB	07.01.08	25.01.08	2w
E	**Project seminars**	10.12.07	14.12.07	1W
F	**Visit by external examiners**	07.02.08	14.02.08	1w
G	**Design and Implementation**			
	• Design interfaces using controls	14.11.07	28.11.07	2w
	• Develop ActiveX control for plotting data graphically	21.11.07	14.03.08	12w
	• Develop communication program between USB and PC	21.02.08	07.03.08	2w
	• Hardware installation	28.02.08	14.03.08	2w
H	**Test and Debugging**			
	• Test project	21.02.08	14.03.08	3w
	• Evaluate test results and correct software developmen	28.02.08	14.03.08	2w
I	**Write formal report**	28.02.08	07.04.08	4w
J	**Project reviews and ready for presentation**	07.04.08	14.04.08	1w
K	**Poster Session**	14.04.08	30.04.08	2w

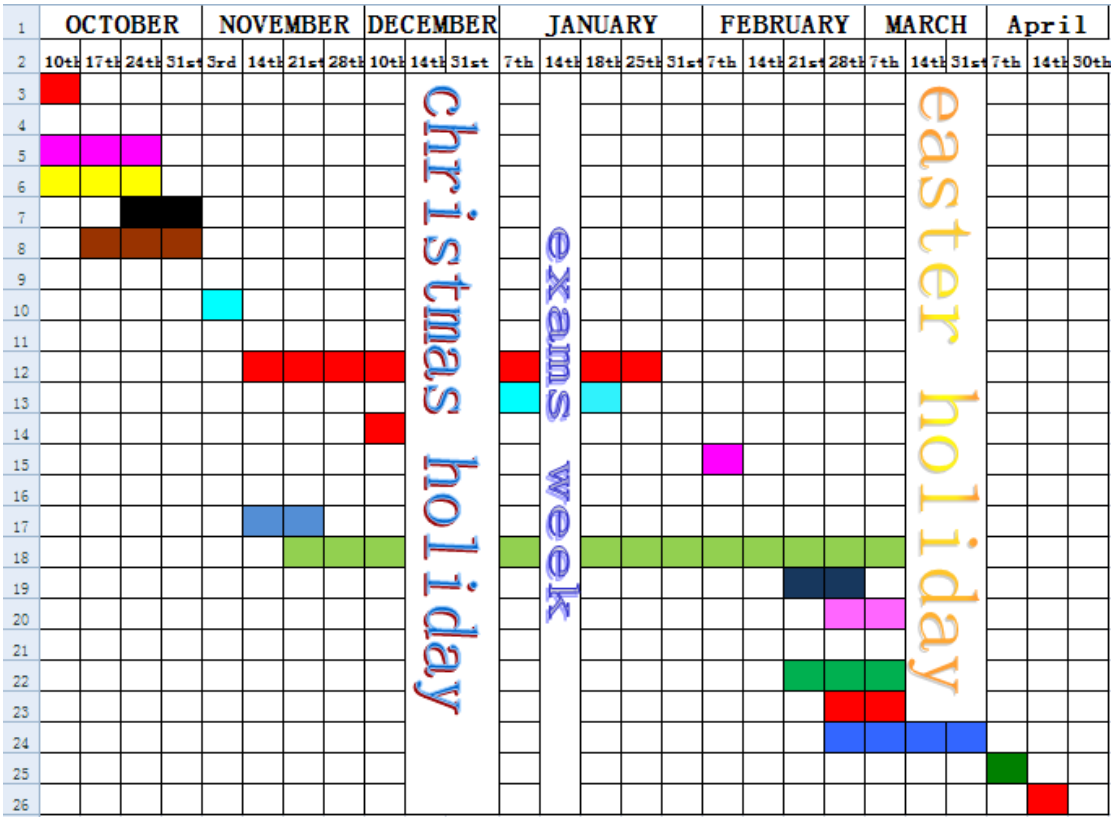


Figure A-3 Gantt chart